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North Colonnade of Old Mosque Near Kutub Minar, Delhi. An Exquisite Example of Ancient Indian Architectural Art.

HOW SHALL THE NEW INDIAN CAPITAL BE BUILT?—[See page 72.]

Agriculture, Manufactures and Railways*

A Study of Capital Values and Net Returns of Three Important Industries

INTRODUCTION.

AGRICULTURE, which includes the production of the food supply and in a measure that of the raw material of manufacture; manufacturing, which is the transformation of raw material into a partly finished state, or into the finished product itself; and transportation, which is the conveyance of materials and products, of passengers and the mails, are the principal industries of the United States, and in this country the most important factor in transportation is the railway system.

It is of the first importance to know what are the amounts of capital invested respectively in agriculture, manufactures, and railways, and the amount and rate of return upon such capital. The impossibility however of ascertaining with absolute exactness the amount of the investments that have been made in these widespread and ramifying industries becomes apparent at the beginning of the inquiry, as does also the inability to make a precise distinction between the amount of investment and present capital value. This is especially true of a new and growing country like the United States, where values often have literally sprung from the ground almost without the investment of capital, and where natural increment has accounted in large part for the current value of land. Even so, the study of capital investment and return, carried out with care and a full appreciation of the difficulties involved, leads to significant results.

First of all must be considered certain essential differences in the character of the capital of these respective industries.

Although buildings, improvements such as fences, drains, etc., and appliances such as implements and machinery, are indispensable for farm cultivation the productivity of farm land in the United States depends in greater measure upon the fertility of the soil than upon the utilization of invested capital. As a growing population demands more and more of farm products, the value of farm land rises as the population increases, especially if it lies contiguous to populous centers. Although the use of continually improving methods of cultivation increases the production of a given area and gives it a greater earning capacity, the declining yield after years of tillage makes necessary the increasing use of fertilizer, and thus tends to offset the larger earnings. Clearly, the land itself is the largest factor in the value of a farm, and the owner does not bring about that increase in value due to the growth of population, which is commonly designated as the "unearned increment."

Investment in a manufacturing plant includes the price paid for the land which forms the site, but the principal investment in the case of a plant of any magnitude is in the buildings and appliances in which and by means of which the processes of manufacture are carried on. In no small measure the return upon capital in manufacture depends upon efficient and economical methods, and upon skill in the designing and marketing of products for which there is demand. The value of the land may increase as other land in the vicinity becomes more valuable, and to this extent the value of a manufacturing plant may be enhanced by unearned increment. The buildings and appliances, however, tend to deteriorate as they are used, involving more rapid depreciation than is suffered by farm land because of tillage.

With a railway, as with a manufacturing plant, the land is an indispensable factor, and its value is also enhanced by unearned increment unless it be considered that it is largely because of transportation service that the value of adjoining land is enhanced, and that therefore in a measure the rising value of railway real estate is a reflex of the service performed by the railways. With a railway, as with a manufacturing enterprise, the principal investment is in the plant; in the case of the railway it is the roadbed, cars and locomotives, buildings, and appliances. With a railway, as with a manufacturing plant, the return upon capital depends in no small measure upon efficient and economical methods of operation, and also upon the vigor with which traffic is secured and developed; and there is rapid depreciation.

Therefore, there is a greater similarity between the railway and manufacturing industries than between either of these and the agricultural industry. A respect in which the agricultural distinctly differs from the manufacturing or railway industry is in the comparatively slight extent to which establishment as a "going concern" affects the capital value of the farm as contrasted with the considerable value which establishment as a going concern attaches to a manufacturing plant or a railway. A farm may change the character of its product or even lie fallow for a year or more without great deterioration in its capital value. This applies in far less degree to a manufacturing establishment and it does not apply at all to a railway, which is obliged to continue its transportation service without cessation. The continuing organization necessary to such permanence as a going concern is alone a considerable factor in its value.

Certain localities and even particular farms may gain a distinctive reputation for the production of certain grades of fruits, or vegetables of live stock, or even of grains which command preferential prices, but in the main the bulk of the products of agriculture are marketed without regard to the immediate locality or the particular farm whence they came. In the case of most manufacturing establishments the distinctive reputation for a particular kind and grade of production is an asset of great value.

So also with a railway company. While a considerable share of the traffic of every railway is non-competitive, there are but few of the railway systems of the United States, which are not dependent upon competitive traffic. In securing such traffic, and especially competitive passenger traffic, the reputation of a railway for efficient transportation is an asset of the highest value, and this reputation can only be gained through the development of an organization that must increase in efficiency.

Value as a "going concern" is therefore no doubt of some importance in the agricultural industry, but it is a prime factor in the aggregate value of a manufacturing establishment or of a railway. The amounts representing capital value used in this study, however, are the book values of the actual investment only, and contain no allowance for the value of patents, trade-marks, good will, or establishment as a going concern.

NATIONAL WEALTH OF THE UNITED STATES.

Because of its significance in relation to this study there is here presented a comparative statement of the national wealth of the United States in 1890, 1900, and 1904 as estimated by the Bureau of the Census. The Census Bureau does not purpose to extend this investigation in the near future to include a period later than 1904.

ESTIMATE OF WEALTH: UNITED STATES.a

Subject.	1890.	1900.	1904.
Real property and improvements—taxed	$35,711,209,108	$46,324,839,234	$55,510,228,057
Real property and improvements—exempt	3,833,335,225	6,212,788,930	6,831,244,570
Farm implements and machinery	494,247,467	749,775,970	844,989,863
Live stock	2,308,767,573b	3,306,473,278	4,073,791,736
Manufacturing machinery, tools and implements	3,058,593,441c	2,541,046,639	3,297,754,180
Gold and silver coin and bullion	1,158,774,948	1,677,379,825	1,998,603,303
Railroads and their equipment	8,296,050,034	9,035,732,000	11,244,752,000
Street railways	389,357,289	1,576,197,160	2,219,966,000

ESTIMATE OF WEALTH: UNITED STATES.a—(Continued.)

Subject.	1890.	1900.	1904.
Telegraphs	701,755,712 (Telegraphs, Telephones, Shipping and canals)	211,650,000	227,400,000
Telephones		400,324,000	585,840,000
Shipping and canals		537,849,478	846,489,804
Pullman and private cars	....	98,836,600	123,000,000
All other	9,185,000,400	15,844,413,661	19,300,132,897
Total	$65,137,091,197d	$88,517,306,775	$107,104,192,410

a Special Report of the Census Bureau on Wealth, Debt, and Taxation, 1907, pp. 27-29.

b This does not include the value of live stock in cities, towns and villages. The value of such live stock is included in the value of live stock for 1900 and 1904, amounting to about one-tenth of the total value.

c Including product on hand, raw and manufactured. These items are partially covered under the heading "all other" in 1900 and 1904.

d This total exceeds the total given on page 29 of the Census report by $100,000,000. The discrepancy is due to an error of addition in the original table prepared by the Census Bureau in 1890.

Inasmuch as the classification of items followed by the Census Bureau in preparing these estimates of national wealth varied somewhat for the respective years, the rates of increase are not strictly comparable throughout. They suffice, however, for the purpose of a broad and general comparison.

Therefore it may be noted that the augmentation in the total estimated wealth of the United States between 1890 and 1904 was $41,967,101,213. This was an increase of 64.4 per cent, or nearly two thirds while the increase in the value of railroads and their equipment for the same period was $2,948,701,966, or 35.5 per cent. The rate of increase in the value of taxed real property and improvements from 1890 to 1904 was 55.4 per cent; in the value of untaxed real property and improvements, 78.2 per cent; in the value of farm implements and machinery, 71.0 per cent, and in the value of street railways, including interurban railways operated by electricity, 470.2 per cent. It will be noted that the value of the railroads, as shown by these reports of the Census, increased from 1890 to 1904 but little more than half as fast as the value of all property, and that the rate of increase in the value of every other form of property for which comparable values are available was considerably greater than in that of the railways.

CAPITAL VALUES OF THE AGRICULTURAL, MANUFACTURING, AND RAILWAY INDUSTRIES.

That the term "capital" as used in the reports of the Bureau of the Census on manufacturers refers to the estimated or book value of the property employed in the business is made clear by the explanation of the term in the instructions to the census enumerators. In 1910, for example, the instructions read as follows: "*Capital invested.* The purpose of this inquiry is to determine the value of property employed by the establishment for the purposes of its productive operation, but not including rented property. Patent rights and good will must not be considered as a part of the capital."

In its reports upon agriculture the Census Bureau uses the term "value of farm property" throughout, in preference to "capital" or "capital value." The value of farm property is the value placed upon it by the owner thereof, modified or adjusted in accordance with prevalent standard values.

The Interstate Commerce Commission has not attempted either to compute or to estimate the value of American railway property, but in its annual reports has shown the gross capitalization, the net capitalization, and the cost of road and equipment as reported by the railways. By "gross capitalization" is meant the total par value of outstanding stocks and bonds. "Net capitalization" is gross capitalization less such part of it as is held by the railways themselves. In other words, net capitalization is the total par value of stocks and bonds owned and held by the general public; that is, the amount of railway capitalization for which the railways are responsible to the public. Net capitalization stands therefore as a far better criterion of railway values than gross capitalization. The "cost of road and eqiupment" of the railways is the book value of road and equipment. No one of these three aggregates has exactly the same basis as the capital value reported for manufactures or the value of farm property reported for agriculture.

The close correspondence of the value of the railways as reported by the Census Bureau for the years 1890, 1900, and 1904 and as shown by the aggregate of their reports of "cost of road and equipment" to the Interstate Commerce Commission for the same years is made clear in the following table. It will be perceived that the valuation for 1904 is indicated at an almost identical amount by the respective authorities.[1]

Year.	Estimate of Census Bureau.	Reports of the railways to the Interstate Commerce Commission.
1890	$8,296.050,000	$7,755,387,000
1900	9,035,732,000	10,263,313,000
1904	11,244,852,000	11,511,537,000

The capital values of the agricultural, manufacturing, and railway industries in 1890, 1900, 1905, and 1910, except as noted, are given in the next table. It must be borne in mind that the significance of these amounts is limited by the qualifications that have been specified. It is not possible to show manufacturing capital for 1890 on a comparable basis with that of 1900, 1905, and 1910; returns for that year in the case of manufacturers are therefore omitted. The reports of the Bureau of the Census are the source of the amounts for agriculture and manufactures; the reports of the Interstate Commerce Commission for the items in regard to the railways. For the railways there are given cost of road and equipment, gross capitalization, and net capitalization. It will be perceived that in each case the cost of road and equipment exceeds the net capitalization, which is the amount of capitalization for which the railways are responsible to the public. The two amounts for 1910 are almost identical. Because of its correlative interest, the population of continental United States in each of the census years 1890, 1900, and 1910 is shown in the table. A census was not taken of either agriculture or the population in 1905.

* Abstract published in the *Railway Age Gazette* from Bulletin No. 39 of the Bureau of Railway Economics, entitled "Comparison of Capital Values—Agriculture, Manufactures and the Railways."

[1] It may be pointed out in this connection that the estimate made by the Census Bureau of railway valuation in 1904 was prepared under the supervision of joint officials of the Census Bureau and the Interstate Commerce Commission. This fact does not explain the close relationship between the cost of road and equipment of railways as returned to the Commission in 1904 and the valuation of railway property as computed by the Census Bureau for the same year. The former represents the value of railway property on the books of the railways themselves; the latter is a wholly original computation of the commercial valuation of railway operating property, arrived at by capitalizing the average net earnings of individual railways and railway systems. The complete difference of method utilized in reaching the respective aggregates for 1904 makes their close correspondence both striking and significant.

CAPITAL VALUE OF AGRICULTURE, MANUFACTURES AND RAILWAYS OF THE UNITED STATES.

	1890.	1900.	1905.	1910.
Agriculture	$16,082,267,689	$20,439,901,164	....	$40,991,449,090
Manufactures	....	8,975,256,000	$12,675,581,000	18,428,270,000
Railways:				
Cost of road and equipment	7,755,387,381	10,263,313,400	11,951,348,949	14,387,816,099
Gross capitalization	9,437,343,420	11,491,034,960	13,805,258,121	18,417,132,238
Net capitalization *b*	7,126,673,041	8,803,156,067	9,940,853,945	14,375,529,748
Population	62,947,714	75,994,575	....	91,972,266

a In the tables of this study giving capital values the statistics presented for agriculture in 1890 and 1900 relate to June 1, and in 1910 to April 15. The statistics for manufactures in each case refer as nearly as possible to January 1, and the statistics for the railways to June 30.

b Up to 1906 the amounts representing net capitalization published by the Interstate Commerce Commission were incomplete to the extent that they did not include income bonds, equipment trust obligations, and miscellaneous obligations in the hands of the public.

The relative importance of the three industries is indicated by this table. In 1910, for example, using round numbers, the aggregate value of American farm property, including real estate, implements and machinery, and live stock, was reported at $41,000,000,000; the amount of capital invested in manufactures was reported as $18,500.000,000; while the total cost of road and equipment of the railways was reported at $14,400,000,000.

The rates of increase in the capital values thus reported, and of the population, are shown in the following table:

PERCENTAGE OF INCREASE IN CAPITAL VALUE.

	1900 over 1890.	1905 over 1900.	1910 over 1905.	1910 over 1900.
Agriculture	27.1	....	....	100.5
Manufactures	....	41.2	45.4	105.3
Railways:				
Cost of road and equipment	32.3	16.4	20.4	40.2
Gross capitalization	21.8	20.1	33.4	60.3
Net capitalization	23.5	12.9	44.6	63.3
Population	20.7	....	....	21.0

For the ten-year period, 1900 to 1910, the rate of increase in the capital value of agricultural property was 100.5 per cent, the rate of increase of capital invested in manufactures 105.3 per cent, and the rate of increase in the cost of road equipment of the railways 40.2 per cent. Gross capitalization of the railways increased 60.3 per cent, and the net capitalization 63.3 per cent. The greater percentage of increase in capitalization than in cost of road and equipment was largely due to the fact that railways to a large extent have not written up on their books the values of their real properties as they increased, and that they have invested large amounts in their properties which they did not charge to property account. For the preceding decade, 1890 to 1900, the capital value of agriculture increased at the rate of 27.1 per cent, and the cost of road and equipment of the railways at the rate of 32.3 per cent. That is, during the earlier decade agricultural value increased in a somewhat lower ratio than railway investment, while during the second decade the rate of increase was two and a half times as high for agriculture and over two and a half times as high for manufactures as for railways. The increases in the capital values of agriculture and of manufactures in this second decade were each more than 50 per cent greater than even the increase in the capitalization of the railways.

As an indication of the extent to which the capitalization of industries, i. e., their outstanding stock and bond issues, exceeds their capital value as reported to the Census Bureau and embodied in this study the following comparison has been made by that Bureau of the two items for all the industrial combinations existent in the United States in 1900:[2]

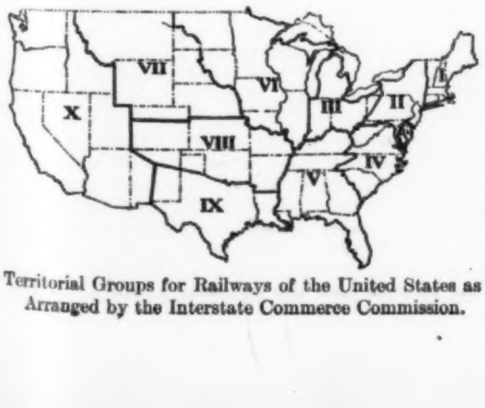
Total capitalization authorized and outstanding............................$3,093,096,000
Total capital, as reported to the Census Bureau............................ 1,461,632,000

Thus the capitalization of these combinations was more than twice as great in amount as the capital value, represented by land, buildings, machinery, tools, and implements, cash, bills receivable, etc. The gross capitalization of the railways was about 12 per cent greater than the cost of road and equipment in 1900, and 28 per cent greater in 1910.

CAPITAL BY INTERSTATE COMMERCE COMMISSION GROUPS.

Statistics as to the cost of road and equipment of the railways are not available for the several States, nor for any geographical area less extensive than the United States as a whole. The Interstate Commerce Commission publishes annually the gross capitalization of the railways for each of the ten territorial groups defined at the time it undertook the compilation of railway statistics. These groups are numbered consecutively and comprise, respectively, the areas indicated in the foregoing map.

[2] See the report of the Census Bureau on manufactures, 1900, Part I, pp. LXXVIII–LXXIX.



Territorial Groups for Railways of the United States as Arranged by the Interstate Commerce Commission.

The gross capitalization of the railways of each of these ten territorial groups was as follows in the years 1890, 1900, and 1910:

RAILWAY GROSS CAPITALIZATION BY INTERSTATE COMMERCE COMMISSION GROUPS.

Group.	1890.	1900.	1910.
I	$377,477,302	$472,329,210	$799,627,536
II	2,032,242,616	2,337,874,067	3,543,053,383
III	1,309,390,715	1,490,997,662	2,414,370,374
IV	410,704,029	631,863,020	960,183,380
V	742,670,372	903,681,993	1,346,913,136
VI	1,818,588,865	2,024,541,064	3,102,203,094
VII	443,136,450	560,763,313	1,047,244,431
VIII	1,047,274,401	1,395,350,723	2,260,370,943
IX	372,982,285	511,034,132	808,905,131
X	882,876,385	1,162,599,776	2,134,260,830

To secure statistics of the amount of capital invested in manufactures and of the value of agricultural property that may be compared with these aggregates of gross railway capitalization by groups, it will be necessary to combine into corresponding groups the returns of agricultural and manufacturing values shown by States in the preceding tables. While the group lines do not in every instance follow State boundaries, yet it will be possible to obtain a very close approximation to the several groups by including the returns of any State, parts of which are in different groups, in the returns of the group in which lies the greater part of its area. The results of this approximation are presented in the next two tables. The first gives the value of the farm property of each group in 1890, 1900, and 1910. This table covers farm property of all kinds, including land, buildings, implements, machinery, and live stock.

VALUE OF FARM PROPERTY BY CORRESPONDING GROUPS.

Group.	1890.	1900.	1910.
I	$585,267,817	$639,645,900	$867,240,457
II	2,637,796,896	2,567,765,165	3,317,411,784
III	2,712,949,906	2,867,896,151	4,800,688,206
IV	810,006,671	914,849,178	1,869,648,447
V	1,325,025,536	1,478,172,491	2,906,501,343
VI	3,654,365,065	5,694,326,155	11,515,526,346
VII	751,230,899	1,230,812,589	3,760,933,478
VIII	1,783,711,403	2,517,208,718	5,902,067,389
IX	662,574,109	1,161,013,179	2,519,866,152
X	1,159,339,387	1,368,211,638	3,531,565,488

The amounts of capital invested in the manufacturing industries of each group in 1900 and 1910 are shown in the following table:

CAPITAL INVESTED IN MANUFACTURES BY CORRESPONDING GROUPS.

Group.	1900.	1910.
I	$1,507,630,000	$2,503,854,000
II	3,656,526,000	6,848,361,000
II	1,037,226,000	2,393,397,000
IV	272,436,000	757,720,000
V	338,999,000	854,345,000
VI	1,241,148,000	2,612,048,000
VII	112,230,000	163,702,000
VIII	370,851,000	872,148,000
IX	164,530,000	438,692,000
X	273,680,000	984,003,000

The following table gives the rates of increase of the capital amounts set forth in the three preceding tables:

PERCENTAGE RATE OF INCREASE.

	1890 to 1900.		1900 to 1910.		
Group.	Agriculture.	Railways.	Agriculture.	Manufactures.	Railways.
I	9.3	25.1	35.6	66.1	69.3
II	*d*2.7	15.0	29.2	87.3	51.6
III	5.7	13.9	67.4	130.7	61.9
IV	12.9	53.8	104.4	178.1	52.0
V	11.6	21.7	96.6	152.0	49.0
VI	55.8	11.3	102.2	110.5	53.2
VII	63.8	26.5	205.6	45.9	86.8
VIII	41.1	33.2	134.5	135.2	62.0
IX	75.2	37.0	117.0	166.6	58.3
X	18.0	31.7	158.1	259.5	83.6

d Decrease.

It will be borne in mind that these tables by groups give railway gross capitalization only. Neither net capitalization nor the cost of road equipment are ascertainable for the respective groups. From 1890 to 1900 the gross capitalization of the railways increased in six of the ten groups at a higher ratio than the value of agricultural property. From 1900 to 1910, however, in all except Groups I, II, and II, where agriculture has not kept pace with other activities, the rate of increase in gross capitalization of the railways has been approximately one half the rate of increase in the value of farm property. From 1900 to 1910 gross railway capitalization has increased in much lower ratio than the capital value of manufacturing, which is far less than the gross capitalization of the manufacturing industries. An exception is in Group I, and the only other exception in Group VII, where the development of railways has been especially necessary to serve the agricultural industries.

RETURN ON MANUFACTURING AND RAILWAY CAPITAL.

Even more difficult and uncertain than a comparison of the capital values of the agricultural, manufacturing, and railway industries is a comparison of the annual returns upon these capital values. Indeed, it has been found impracticable even to attempt an estimate of the returns from agriculture that would be suitable for such a comparison. In the case of manufactures and railways, however, the operating or running expenses and the taxes may be ascertained, and thus an approximation may be had to the net returns on capital. In this manner, for the following tables the gross and net value of the products of the two industries have been computed upon as nearly a comparable basis as possible. The net return has been ascertained by deducting from the respective gross value of products in the case of manufactures, and from gross earnings in the case of the railways, all operating expenses, including taxes. In each case, interest on capital is included in the net return.

GROSS AND NET RETURNS FROM MANUFACTURES.

	1900.	1905.	1910.
Gross returns:			
Gross value of products	$11,406,927,000	$14,793,903,000	$20,672,052,000
Expenses: *b*			
Cost of materials	6,575,851,000	8,500,208,000	12,141,791,000
Salaries and wages	2,389,132,000	3,184,884,000	4,365,613,000
Miscellaneous expenses, including taxes	905,442,000	1,453,168,000	1,945,676,000
Total	$9,870,425,000	$13,138,260,000	$18,453,080,000
Net return	$1,536,502,000	$1,655,643,000	$2,218,972,000

GROSS AND NET RETURNS FROM RAILWAY OPERATION.

	1890.	1900.	1905.	1910.
Total operating revenues	$1,051,877,632	$1,487,044,814	$2,082,482,406	$2,750,667,435
Expenses:				
Total operating expenses, including wages	692,093.971	961,428,511	1,390,602,152	1,822,630,433
Taxes	31,207,469	48,332,273	63,474,679	103,795,701
Total	$723,301,440	$1,009,760,784	$1,454,076,831	$1,926,426,134
Net return, including interest on capital	$328,576,192	$477,284,030	$628,405,575	$824,241,301

It should be pointed out that the item "salaries and wages" does not include salaries paid to proprietors or firm members interested in non-corporate manufacturing establishments. There were 273,265 of these proprietors and firm members in 1910 for whom no definite salaries were reported. The railways are virtually all owned by corporations, all employees from president down being paid a definite salary or wage. To some extent, therefore, the expenses shown for the manufacturing and railway industries are not comparable. On the other hand, non-corporate manufacturers produced in 1910 only one fifth of the total value of products manufactured in that year, while the average size and importance of the individual non-corporate establishment was so small that the return to the proprietor or firm owner could not be differentiated between wage and profit.

Depreciation of the road and equipment of railways is, under the accounting system prescribed by the Interstate Commerce Commission, provided for through the operating expense account. The practice of manufacturing establishments in regard to depreciation of plant is not uniform, but it may be supposed that prudent management will, in the long run, charge the cost of repairs and replacement (which may be said to stand for a depreciation account where no such definite account is maintained) to running expenses.

As has been specified in these pages, there have been variations in the requirements of the Bureau of the Census at different times for ascertaining the capital value of manufactures. Moreover, in computing such vast aggregates there is always the necessity for adjustments of one kind and another so that different persons may not always arrive at identically the same results in handling the intricate data. Indeed, the same person may be obliged at one time to give consideration to various factors that bring about results varying from those of a similar adjustment at another time. Futhermore, the income account here shown for manufactures differs from that of the railways in the fact that the reported railway returns represent cash actually received, while the reported value of products manufactured in any year is not only partially made up of cash already taken in, but is also in part an estimate of the probable market value of such portion of the product as is not yet sold, and in part consists of outstanding accounts the settlement of which may entail loss. In other words, the manufacturing returns are partially at least based on estimates. It therefore cannot be too strongly insisted that the tables and the deductions therefrom on these pages are of broad and general significance only. It is believed, however, that possible variations do not impair such broad and general significance.

In the next table are set forth the capital values of the two industries, the return on capital as expressed in the preceding tables, and the percentage of that return. It will be perceived that the years for which there is available complete information that is approximately comparable for each industry are those designated as 1900 and 1910. These may be considered to mark the beginning and the end of a decade which comprised a fairly distinct industrial era. In 1900 the country was on the high tide of recovery from prolonged industrial depressions; in 1910 it was enjoying exceeding prosperity, both the gross and the net earnings of the railways attaining a higher mark than for any preceding or subsequent year. It will be noted that in the case of the railways the percentage of net returns is computed on the cost of road and equipment, which is the item comparable with the capital value of manufacture as given.

COMPARISON OF NET RETURNS ON CAPITAL.

	1900.	1905.	1910.
Manufactures:			
Capital	$8,975,256,000	$12,675,581,000	$18,428,270,000
Net return on capital	1,536,502,000	1,655,643,000	2,218,972,000
Per cent. of net return	17.119	13.062	12.041
Railways:			
Cost of road and equipment	$10,263,313,400	$11,951,348,949	$14,387,816,099
Net return	477,284,030	628,405,575	824,241,301
Per cent. of net return	4.650	5.258	5.729

In 1900 the percentage of net return upon capital in manufactures was nearly four times as great as that on the cost of road and equipment of the railways. In 1905 it was two and one half times as great.

From 1900 to 1910 the capital in manufactures increased 105 per cent, and the cost of road and equipment of the railways increased 40.2 per cent. In the latter year the percentage of net return on capital in manufacture was two and one tenth times as great as in railways.

Fig. 1.—The Primrose, a Favorite House Plant Which Poisons the Hand That Touches It.

Fig. 2.—Inflammation Produced by a Leaf of *Cortusa*.

Plants Venomous to the Touch*

By Dr. A. Nestler

Fig. 3.—The Bear's Ear or *Cortusa*, a More Virulent Alpine Cousin of the Primrose.

ALL overground parts of the common nettle produce, by contact with the skin, a local inflammation, characterized by intense itching and small red pimples, which soon disappear. The bristles of the nettle (Fig. 4) terminate in points made brittle by silica which on penetrating the skin break off and permit the escape of a minute quantity of a quickly-acting poison of unknown composition.

A very different and insidious action is exerted by some species of *Primula*, notably the cup primrose (*P. obconica*, Fig. 1) and its many cultivated varieties. Here, also, the irritating substance is produced and applied by hairs, but these hairs are too soft to penetrate the skin. They terminate in globular glands, which exude a poisonous secretion that acts so slowly that several days may elapse before any symptoms of inflammation appear. The skin then becomes covered with blisters, and itches painfully, especially at night. A single contact with the plant sometimes produces an inflammation that lasts two or three weeks. The disease may be protracted indefinitely by repeated infection and may be carried by the hands to every part of the body. A university professor, who kept primrose growing in his bedroom, long suffered tortures without suspecting their cause. His face and hands itched so intolerably that he could not sleep, and used to sit up half the night bathing his hands in cold water and rubbing them until they bled. For a time he was compelled to give up his work, and was treated by many physicians and dematologists in vain. Finally he read of the poisonous action of the primrose, banished his cherished plants from his bedroom, and his sufferings abated.

Long experience and direct experiments have convinced me that no one is entirely immune to primrose poison. I have known gardeners to be poisoned severely after they had cultivated thousands of primroses during many years without the slightest inconvenience. The Chinese primrose (*P. sinensis*) produces the same effect, but only on especially susceptible persons. Other species of *Primula* are equally poisonous, but they are of less importance because they are seldom cultivated except in botanical gardens.

The poisonous character of the bear's ear (*Cortusa Mattpioli*, Fig. 3), a beautiful plant of the primrose family, which grows in shady Alpine ravines, was recognized more than 300 years ago, but was subsequently forgotten. In 1609 the physician and botanist, Charles de l'Ecluse, better known as Clusius, wrote that the fresh leaves of the *Cortusa*, not crushed or broken, applied for an instant to a lady's cheeks, produce a "lovely blush" which is not followed by any permanent mark or other ill effect. These words may be interpreted to mean, either that crushed leaves produce no effect or that they injure the skin. In order to test the power of the leaves I applied a fresh and unbroken one to my left wrist for two hours. Its removal revealed the "lovely blush" described by Clusius, but this was only the beginning. On the following day, 33 hours after the leaf was applied, my wrist presented the appearance shown in Fig. 2. There was a thick red swelling, covering two square inches and surrounding two large and many small blisters. The eczema continued to spread for 17 days, and covered an area of 15 square inches on the fourteenth day. The symptoms were similar to those of primrose poisoning, but much more severe, including continuous formation of blisters, intense itching, copious effusion of blood-serum and swelling of the whole forearm and hand.

At the same time I had gently rubbed a part of my right arm with a *Cortusa* leaf, without tearing the leaf. The inflammation, which made its first appearance two days afterward, was similar to that of the left wrist, but less extensive. Meanwhile I had been studying and touching the leaves and involuntarily carrying infection to the other parts. The lids of one eye and the tips of both ears were blistered and swollen, and many blisters appeared on the neck and the fingers.

From these experiments and from the words of Clusius, I conclude that the poison of the *Cortusa* is produced on the surface of the leaf, not in its interior. The leaves and stalk bear glandular hairs similar to those of the primrose, which produce a secretion that certainly irritates the skin, although it is unlike the corresponding primrose secretion in other respects. As the effects are not manifested immediately it is very probable that many botanists have suffered from them, without knowing their cause.

Many cases of poisoning of the skin by certain varieties of wood have been reported in recent years. An English writer, Smith, stated in 1906 that the so-called "Borneo rosewood," which is a favorite material for toys and ornamental objects because of its beautiful color and marking, causes inflammation of the hands, arms and eyes of wood-workers, and that the back of a man had been affected merely by carrying a bag of shavings of this wood. Similar poisonous properties have been ascribed to many other woods, particularly East Indian and West Indian satinwood.

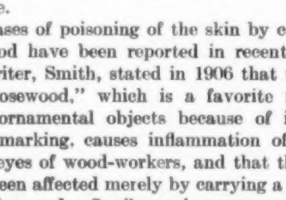


Fig. 4.—Bristle of Nettle Magnified 200 Times.

Experiments made in England with these satinwoods and Borneo rosewood yielded negative results, but this fact does not prove the absence of poisonous properties, for the effects of such poisons differ greatly in different individuals. Some persons are very susceptible and others appear to be immune.

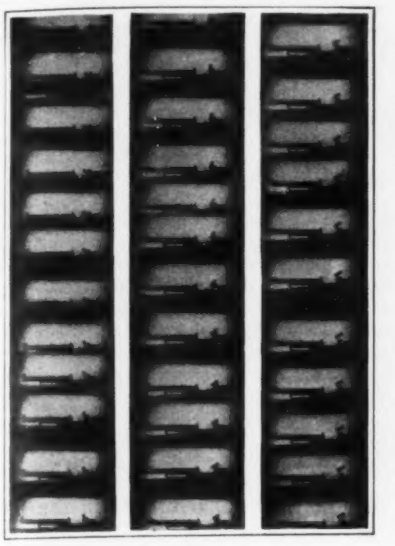
I have studied the effects of East Indian satinwood and two other woods, reputed to be poisonous to the skin. East Indian or Asiatic satinwood, also called silkwood, is produced by *Chloroxylon Swietenia*, a tree which grows in India and Ceylon. It is a pale yellow wood with a beautiful satiny luster and is so dense that it sinks in water. In English shipyards, where this wood is used for fine wainscoting, it has produced painful eruptions on the hands and faces of workmen. All experiments made on my own person, by application of fine sawdust and extracts of the wood, yielded negative results.

I can assert with confidence, however, that the other two varieties of wood that I have tested, possess poisonous properties. One of these varieties is a soft wood, used chiefly for veneers, and called "satin walnut" or sometimes (incorrectly) "East Indian satin-wood." It is the product of the American sweet gum tree (*Liquidambar styraciflua*). Some writers assert that this wood is poisonous to the skin, and others claim that it is perfectly harmless. Neither the wood nor its sawdust cause inflammation by several hours' contact with the skin, but an irritating substance can be extracted from the wood by means of pure ether. The evaporation of the ether leaves a residue which resembles stearin. When a bit of this substance as big as a millet seed is applied to the skin, it produces, after a few hours, severe inflammation and blisters, which persist several days. Hence it is still undecided whether or not mere contact with this wood can produce inflammation of the skin in exceptional cases.

The irritating properties of cocobolo wood, on the contrary, are not open to doubt. This is an orange-red wood, with conspicuous black stripes. It is heavier than water and is used for inlaying and the backs of brushes. It is probably the product of a species of *Cocobolo* indigenous to tropical America. A small quantity of the sawdust bound by court plaster to a sensitive and moistened part of the skin for a few hours produces severe inflammation and blistering, which make their appearance one or more days after the application. The intense itching at night which accompanies primrose and *Cortusa* poisoning is also produced by cocobolo. Workers in cocobolo must often suffer these annoyances, for small particles of the wood may adhere to a perspiring skin for hours.

The excessively irritating effect of the so-called poison ivy (*Rhus toxicodendron*), a species of sumach common in the United States, has long been known and frequently investigated. Its cause is a resinous substance which is present in all parts of the plant. Merely touching uninjured parts of the plant cannot in this case produce any toxic effect. Transmission of the poison through the air is out of the question, and mere proximity to the plant cannot therefore cause any ill effects. A remedy commonly recommended for poisoning from this plant consists of an alcoholic solution of lead acetate. As a matter of fact, washing after contact with the plant will sometimes prevent the trouble.

* Adapted from *Die Umschau*.


a b c
Fig. 2.

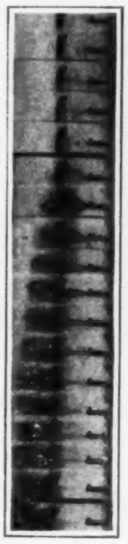
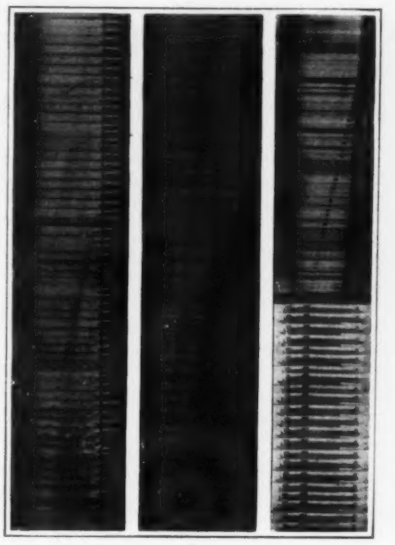


Fig. 3.


a b c-d
Fig. 4.

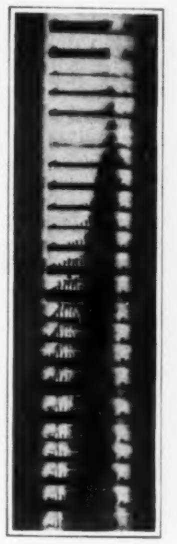


Fig. 5.

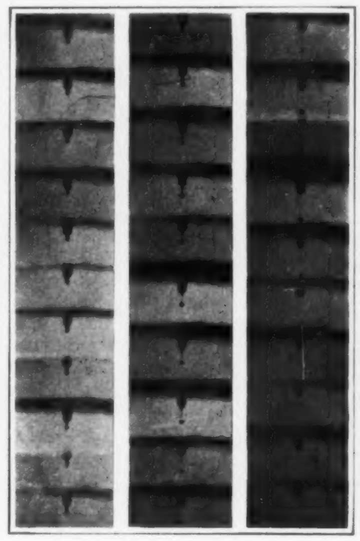

a b c
Fig. 6.

Fig. 2.—*a, b, c,* shows records of a self-charging pistol at 10,000 sparks per second; and working of pistol-lock and discharge of empty cartridge. Fig. 3.—Shows frequency of 6,400 sparks per second; a piece of wood in front of pistol mouth being gradually crushed during shooting. Fig. 4.—*a, b, c-d,* represents records at different frequencies, *a,* 52,600 sparks; *b,* 72,000; *c,* 92,000; and *d,* 40,000. Fig. 5.—Views of the piercing of a lead tube, water filled, taken at rate of 8,400 sparks per second. Fig. 6.—*a, b, c,* shows cinematographically the falling of a drop, at spark frequency of only 250 per second.

One Hundred Thousand Photographs Per Second

High-Frequency Electric Sparks Used as a Source of Intermittent Light

By the Berlin Correspondent of the Scientific American

The remarkable sensitiveness of the photographic plate has allowed phenomena of extremely short duration to be fixed, especially by using electric sparks as an instantaneous lighting of great intensity. Although such sparks only last an extraordinarily short time, they give a perfectly sharp picture of even the most rapidly moving bodies. Lucien Bull at the Marey Institute was the first to design on this basis a cinematographic method allowing rapid motion to be decomposed into its phases and reconstituted on a screen. By means of an induction coil he produced 2,000 sparks per second, recording the phenomenon in a series of cinematographic pictures on a film wrapped round a drum. A further advance was made some years ago by Prof. Cranz, whose ballistic cinematograph allows 800 views of the same phenomenon to be taken at a frequency of 5,000 per second. This apparatus is worked with a high-frequency alternate-current generator and a resonance induction coil. The film band wrapped round two drums, travels at the maximum speed of about 120 meters per second. While the frequency of pictures can be varied between given limits, the apparatus should always be readjusted to resonance.

The latest advance in the same direction, is the apparatus recently submitted to the German Physical Society by Prof. C. Cranz and B. Glatzel. This is practically independent of any resonance adjustment and allows the frequency of pictures to be varied within much wider limits, viz., from about 200 to 100,000 per second. This enormous higher limit, if necessity occurred, could even be extended.

In designing their new apparatus, Messrs. Cranz and Glatzel have endeavored to avoid any drawbacks inherent in previous methods, such as the difficulty in altering the frequency of sparks, a limitation in the available energy and defects of insulation connected with the use of statical charges.

High-frequency vibrations generated in the well-known manner by means of a damped spark-gap and vibratory circuit, in connection with a direct-current circuit, serve to produce the electric sparks. C_1 (Fig. 1) is a capacity consisting of mica condensers variable between 25,000 and 600,000 centimeters. The self-induction L_1 is very small and accordingly insures a dead-beat impulse as pure as possible in the primary circuit, coupled to the secondary which comprises the self-induction L_2 and the small capacity C_2 (1,800 centimeters). Flat coils applied immediately on one another are used in the primary and secondary circuits, thus warranting a coupling as close as possible. The spark-gap F used for lighting is arranged close to a short-focus concave mirror and connected up in parallel to the capacity. The concave mirror projects a picture of the spark-gap on the photographic objective O, which in its turn reproduces the phenomenon of motion occurring at P on a rotating film wrapped round a drum 89 centimeters in diameter which is driven at a maximum speed of 9,000 revolutions per minute. The number of turns is determined by a tachometer.

The number of impulses in the primary is dependent on the capacity (being directly proportional to it) and on the direct-current intensity and the length of the damped spark-gap. The last in the case of the Scheller alcohol spark-gap, is adjusted micrometrically. The tension of the available direct-current being about 700 volts, the frequency of primary impulses is readily and safely adjusted to any figure desired.

In arranging the secondary, a special point was made of reducing the inertia of the lighting spark-gap sufficiently to produce sharp instantaneous views on the rotating film, even at the highest spark frequencies (100,000). Messrs. Cranz and Glatzel use an air spark-gap actuated by a lively air current. While magnesium electrodes would have been especially suitable because of their intense photographic effects, they had to be replaced by copper electrodes on account of their insufficient damping.

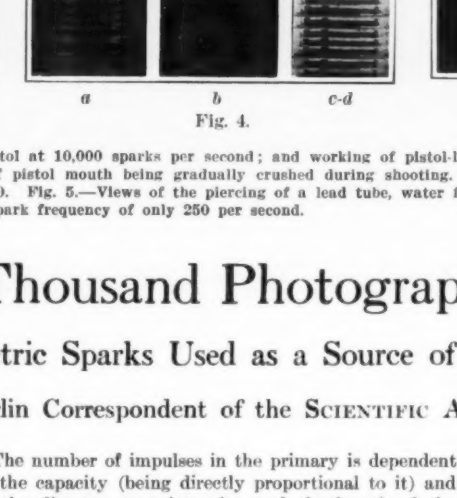


Fig. 1.—Diagram of Apparatus Which Allows Frequency of Photographs up to 100,000 per second.

This method has been applied to the recording of all sorts of ballistical as well as physical processes. The ballistic phenomena of a self-charging pistol were, for instance, recorded with a normal charge, the initial speed being about 280 meters per second, the trigger being released by electro-magnetic means. Fig. 2 *a, b, c,* show such records taken at a frequency of about 10,000 sparks per second, representing the working of the pistol-lock and especially the discharge of the empty cartridge. Fig. 3 has been taken with 6,400 sparks per second, a piece of wood in the front of the mouth of the pistol being gradually crushed during the shooting process. This crushing is seen to occur much more slowly and to grow on continually, even after the projectile has long left the wood.

Fig. 4 (*a, b, c*) represents shooting records at different frequencies, *a* corresponding to 56,600 sparks, *b* to 72,000, *c* to 92,200 and *d* to 40,000 per second. Part of the powder gases is seen under the enormous pressures to leave the barrel before the projectile, the last, and then the bulk of the gases, only following after some time. The different speeds of propagation of the powder gases and the projectile are distinctly recognized.

This method will be used for elucidating a number of problems connected with the working of small arms, such as the determination of recoil and the piercing of armored plates.

Fig. 5 represents the piercing of a lead tube filled with water which is provided at its upper side with a number of holes allowing the water to escape; its ends are closed with caoutchouc membranes. The projecting water jets show most forcefully the propagation of pressure in the water on the entrance of the projectile. These views have been taken at the rate of 8,400 sparks per second.

Fig. 6 (*a, b, c*) finally represent by cinematographic means a comparatively slow process, viz., the falling of a drop, the frequency of sparks being only about 250 per second. This is only intended to show how simply physical processes can be recorded by the new method in all their various phases.

Action of Acids on Concrete

Concrete drains have suffered more or less damage, some of them in comparatively short periods from the time of their construction. In every case the destructive action was traced to the presence of acid in the water which reached the drains either internally or externally. In one case the swampy soil surrounding the drain contained iron pyrites, and the water became charged with sulphuric acid; in the other cases, the air in the drains was heavily laden with hydrogen sulphide, which slowly oxidized to sulphur and sulphuric acid. Other mineral and organic acids, such as hydrochloric, oleic, acetic acids, and carbon dioxide were found almost as noxious. It is concluded that the destructive action of acids is due to two causes: The formation of certain calcium and aluminium compounds, especially calcium sulphate, which is accompanied by a large increase in volumes; and the formation of soluble compounds, especially calcium bicarbonate, which dissolve and cause the concrete to collapse. The chief remedies proposed are: To provide adequate ventilation inside the drains; to use dense, non-porous clinker, poor in lime, as basis for the concrete; and to cover the exposed surfaces of the concrete with a coat of tar, or, best of all, to protect the foundations of the drains with tar felt or asphalt.—*Mines and Minerals.*

Power Census of the United States*

Ninety Per Cent of the Total Power Produced by the Consumers Themselves

By Davis H. Tuck

In 1909, it is reported in the thirteenth United States census, 18,760,686 primary horse-power was generated or rented by manufacturing establishments in the United States. Table 2 shows the distribution.

Ninety per cent of the horse-power in 1909 was that of engines or motors owned by the manufacturing establishments themselves, and 10 per cent was rented power, mostly electric. Especially striking is the increased use of gas engines and of electric power, both that rented from outside concerns and that generated by the manufacturers. The total horse-power of electric motors in 1899, including those operated by purchased current and by current generated in the establishment, was 492,936; in 1909 it was 4,817,140, nearly ten times as great.

Renting electric power is rapidly becoming more common among small establishments, while there is a tendency for the large concerns to use electric motors for applying power which they themselves generate.

The largest amount of electric power is used by the steel works and rolling mills, the next largest being the foundries and machine shops. In the former the electric power is a little over one third of the total amount of primary power and in the latter nearly three fourths.

Table 1 shows, in geographic divisions, the amount of each of the several kinds of power used in manufacturing industries in 1909. The relative total amount used is largely dependent upon the character of the industries predominant in each division or state, and the extent to which the different kinds are used depends upon the character of the industries and the situation of each State as to supplies of coal, petroleum and gas and the availability of water power.

In every State except Maine and Vermont, steam engines are the most important source of power. The proportion which gas-engine power represents of the total is larger in the East North Central division than in any other division, partly on account of the proximity of gas wells. The Middle Atlantic States rank next in the proportion of the total developed by gas engines.

For power obtained by waterwheels owned by the manufacturing establishments, New England ranks far ahead of the other divisions both in the absolute amount of power and in the proportion which water power represents of the total. More than two fifths derived from waterwheels owned by manufacturing establishments is found in New England, and more than one fourth of the power of the New England factories is derived from waterwheels. The Middle Atlantic division ranks next.

The largest absolute amounts of power of electric motors (including both those operated by current generated in the establishment and those operated by purchased current) are reported from the Middle Atlantic, the East North Central and New England divisions.

The leading individual States using gas engines to develop power are Pennsylvania, Indiana, Ohio, New York, Illinois, Kansas and New Jersey. In the use of waterwheels to develop power the States are New York, Massachusetts, Wisconsin, New Hampshire, Vermont, Connecticut, Minnesota, Pennsylvania, Oregon, Virginia, North Carolina and Michigan.

In the absolute amount of electric power for manufacturing, Pennsylvania leads, followed by New York, Ohio, Massachusetts, Illinois, Indiana and New Jersey.

TABLE 1

Division and State	Total horse-power (excluding duplication)	Owned by Establishments Reporting: Steam engines	Gas engines	Water wheels	Water motors	Other	Rented: Electric motors	Other	Electric Motors: Total [1]	Run by current generated by establishment
United States	18,680,776	14,202,137	754,083	1,807,144	15,449	29,293	1,749,031	123,639	4,817,140	3,068,109
Geographic divisions:										
New England	2,715,121	1,656,911	44,451	751,270	3,412	2,055	218,642	38,380	663,143	444,501
Middle Atlantic	5,531,502	4,151,662	274,274	406,541	3,947	11,736	568,723	54,619	1,737,236	1,168,513
East North Central	4,382,070	3,491,418	283,450	206,393	2,048	4,766	375,876	18,119	1,297,447	921,571
West North Central	1,101,990	838,988	57,434	82,791	3,539	939	115,002	3,297	266,534	151,532
South Atlantic	1,837,401	1,434,221	36,688	184,431	1,082	5,321	171,146	4,512	343,393	172,247
East South Central	1,036,560	953,511	12,270	29,040	275	1,680	38,580	1,194	108,409	69,829
West South Central	873,350	805,640	29,291	3,060	48	2,513	31,807	991	78,893	47,086
Mountain	400,766	306,786	4,186	21,345	193	224	66,956	1,069	113,984	47,028
Pacific	802,016	563,000	12,037	62,273	900	49	162,299	1,458	208,101	45,802
New England:										
Maine	459,590	168,595	6,583	253,830	1,912	179	27,203	1,297	54,266	27,063
New Hampshire	293,991	139,128	1,238	127,490	521	30	21,209	4,375	45,351	24,142
Vermont	159,445	64,252	2,160	78,881	181	415	12,917	639	21,233	8,316
Massachusetts	1,175,071	834,701	18,326	185,996	520	895	109,996	24,637	402,492	292,496
Rhode Island	226,740	175,293	3,300	31,376	41	39	13,697	2,994	42,130	28,433
Connecticut	400,275	274,942	12,844	73,697	237	497	33,620	4,438	97,671	64,051
Middle Atlantic:										
New York	1,997,662	1,080,877	99,899	304,221	1,397	3,583	389,945	27,740	689,976	300,031
New Jersey	612,293	529,668	20,867	18,558	1,118	180	33,157	8,745	182,475	149,318
Pennsylvania	2,921,547	2,541,117	153,508	53,762	1,432	7,973	145,621	18,134	864,785	719,164
East North Central:										
Ohio	1,583,155	1,362,134	103,801	15,777	330	1,586	93,592	5,935	417,844	324,252
Indiana	633,377	448,528	109,105	7,446	447	599	65,548	1,704	233,193	167,645
Illinois	1,013,071	838,190	37,025	12,178	513	1,433	117,007	6,716	398,621	281,614
Michigan	598,288	465,520	13,988	41,442	577	16	74,270	2,475	133,064	58,794
Wisconsin	554,179	377,037	19,531	129,550	181	1,132	25,450	1,289	114,725	89,266
West North Central:										
Minnesota	297,670	199,777	7,174	56,631	2,939	25	30,297	827	52,212	21,915
Iowa	155,384	121,882	8,025	6,326	85	147	18,463	456	40,736	22,273
Missouri	340,467	280,480	11,159	3,532	206	5	44,056	1,020	106,941	62,885
North Dakota	13,196	10,170	1,304	530	......	......	1,164	28	1,698	534
South Dakota	17,666	12,257	2,784	927	12	......	1,683	3	2,084	401
Nebraska	64,466	44,806	4,408	7,361	75	76	7,530	210	15,942	8,412
Kansas	213,141	169,607	22,580	7,484	222	686	11,809	753	46,921	35,112
South Atlantic:										
Delaware	52,779	42,266	766	5,183	12	......	4,502	50	17,910	13,408
Maryland	218,244	181,326	5,736	11,953	121	1,069	17,108	931	44,921	27,813
District of Columbia	16,563	12,169	1,073	775	......	43	2,433	70	4,527	2,094
Virginia	283,928	221,303	3,664	45,122	33	38	13,356	412	42,043	28,687
West Virginia	222,896	187,380	16,952	12,901	71	......	5,330	253	28,543	23,213
North Carolina	378,556	271,944	2,356	41,619	307	1,035	60,044	1,281	86,002	25,958
South Carolina	276,378	193,052	1,264	38,422	75	2,400	41,130	35	67,620	26,490
Georgia	298,241	240,264	3,380	28,288	400	536	23,890	1,423	44,264	20,374
Florida	89,816	84,508	1,497	168	3	200	3,353	87	7,563	4,210
East South Central:										
Kentucky	230,224	207,591	4,724	5,320	57	915	11,314	303	31,268	19,954
Tennessee	242,277	215,338	1,853	9,670	107	4	14,666	629	29,586	14,920
Alabama	357,837	328,275	4,616	13,812	111	732	10,104	187	30,928	29,824
Mississippi	206,222	202,307	1,077	238	......	30	2,496	65	7,627	5,131
West South Central:										
Arkansas	173,088	168,152	1,374	639	35	52	2,581	255	7,417	4,836
Louisiana	346,652	331,370	3,496	65	10	2,401	9,077	233	27,139	18,062
Oklahoma	71,139	56,643	8,676	470	2	......	5,281	67	7,887	2,606
Texas	282 471	249,475	15,745	1,886	1	60	14,868	430	36,450	21,582
Mountain:										
Montana	60,402	49,654	223	13,583	63	......	26,504	375	27,301	707
Idaho	42,804	35,529	242	2,403	4	......	4,606	20	8,409	3,803
Wyoming	7,628	6,467	182	456	9	......	514	......	801	287
Colorado	154,615	135,645	1,464	1,377	49	105	15,874	101	35,944	20,070
New Mexico	15,465	11,781	365	74	......	......	3,245	......	4,586	1,341
Arizona	30,140	34,193	1,285	129	......	19	3,314	200	15,100	11,786
Utah	42,947	28,984	226	2,926	71	100	10,592	48	15,402	4,810
Nevada	7,765	4,533	201	397	2	......	2,307	325	6,441	4,134
Pacific:										
Washington	297,807	257,230	1,494	7,842	223	19	30,951	138	43,615	12,664
Oregon	175,019	112,244	428	47,041	397	......	14,811	98	20,802	5,991
California	329,100	193,526	10,115	7,390	280	30	116,537	1,222	143,684	27,147

[1] Includes the horsepower of motors run by rented current and also of those run by current generated by the establishment.

TABLE 3

Power	Number of Engines or Motors: 1909	1904	1899	Horsepower: 1909	1904	1899	Per Cent. Distribution of Horsepower: 1909	1904	1899
Primary power, total	408,472	231,363	168,143	18,680,776	13,487,707	10,097,893	100.0	100.0	100.0
Owned	209,163	169,774	168,143	16,808,106	12,854,805	9,778,418	90.0	95.3	96.8
Steam	153,482	127,267	130,710	14,202,137	10,825,348	8,139,579	76.0	80.3	80.6
Gas	34,352	21,515	14,334	754,083	289,423	134,742	4.0	2.1	1.3
Water wheels	20,126	19,595	23,099	1,807,144	1,641,949	1,454,112	9.7	12.2	14.4
Water motors	1,203	1,397	([1])	15,449	5,931	([1])	0.1	([2])	([1])
Other	......	......	......	29,293	92,154	49,965	0.2	0.7	0.5
Rented	199,309	61,589	([1])	1,872,670	632,902	319,475	10.0	4.7	3.2
Electric	199,309	61,589	([1])	1,749,031	441,589	182,562	9.4	3.3	1.8
Other	......	......	......	123,639	191,313	136,913	0.7	1.4	1.4
Electric motors	388,854	73,119	16,891	4,817,140	1,592,475	492,936	100.0	100.0	100.0
Run by current generated by establishment	189,545	73,119	16,891	3,068,109	1,150,886	310,374	63.7	72.3	63.0
Run by rented power	199,309	([1])	([1])	1,749,031	441,589	182,562	36.3	27.7	37.0

[1] Not reported. [2] Less than one-tenth of 1 per cent.

* Reproduced from *Power*.

Green Vegetables and Their Uses in the Diet

It used to be said that a French housewife could feed her family upon what an American family would throw into their garbage barrel. This is probably no longer true. Though the abundance of food-products in the United States, and inveterate tradition, may still have the effect of keeping Americans somewhat behind the older populations in this matter of domestic economy, it is impossible to doubt that the influx of Germans, Italians and other new elements of population from Continental Europe has taught us the use as food of many vegetables and parts of vegetables which had formerly seemed useless.

In a bulletin on "Green Vegetables and their Uses in the Diet," Mr. C. F. Langworthy, Chief of Nutrition Investigations in the Department of Agriculture, has done much to spread information which ought to be helpful at this time, when the cost of living is a subject of incessant complaint. Even if much of the matter set forth in this bulletin is already familiar to the well-informed housewife, there are many who are by no means well-informed; and authoritative statements emanating from a Government bureau, and based upon careful experiments, should have some practical effect upon the dietary usage of the millions.

Mr. Langworthy's summing up is a plea for the increased use of succulent vegetables in American diets. This increased use, he predicts, will come with improved methods of production and transportation. It is not claimed, of course, that green vegetables add much to the nutrient and fuel values of food; but quite as important as these actual values is the hygenic effect which these vegetables produce in three ways: the supply of necessary mineral matter; added bulk, which is necessary for the proper digestion of the more concentrated food materials; and variety, which is so necessary for the maintenance of healthy appetite. "The great number of fancy foods, pies, cakes, and so on, which American housewives so often consider necessary, are often referred to as showing their ingenuity in providing variety from a few staple materials. They can get much greater variety without anything like as much labor by utilizing such fruits and vegetables as those discussed in this article."

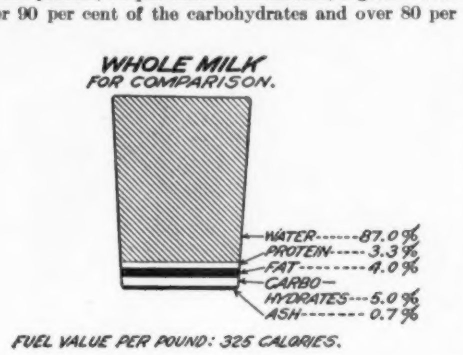
To go back to the beginning of the bulletin, we are told that okra, a native African vegetable, has been cultivated for now more than a thousand years, and that rhubarb was introduced into Europe as early as the tenth century. On the other hand potatoes—as everyone knows—and Indian corn are the agricultural gifts to civilization of the aboriginal Red Man. Tomatoes are one of the newest foodstuffs in existence, having been, in their undeveloped form, regarded as merely ornamental until within the last two generations. It is comforting to see the bugaboo of cancer, as a result of eating tomatoes, disposed of as "without foundation" on the authority of this Government bulletin.

Among the most recent additions to the list of edible green vegetables given here are New Zealand spinach, udo and dasheen. The introduction of new varieties is part of the work of the Department of Agriculture, but there appears to be no provision for teaching American cooks how to use as additions to ordinary diet such easily obtainable things as the leaves of the grape vine. These leaves are used in Turkey in the preparation of several dishes, one being a sort of forcement balls which are a characteristic of wedding banquets. Another exotic addition here suggested is the nasturtium flower, though nothing is said of the use of the nasturtium seed vessel, which makes an excellent pickle in some countries. From the Chinese we may hope some day to learn the merits of bamboo shoots as food, canned bamboo shoots being already "not uncommon in American cities and towns where Chinese foods are on sale."

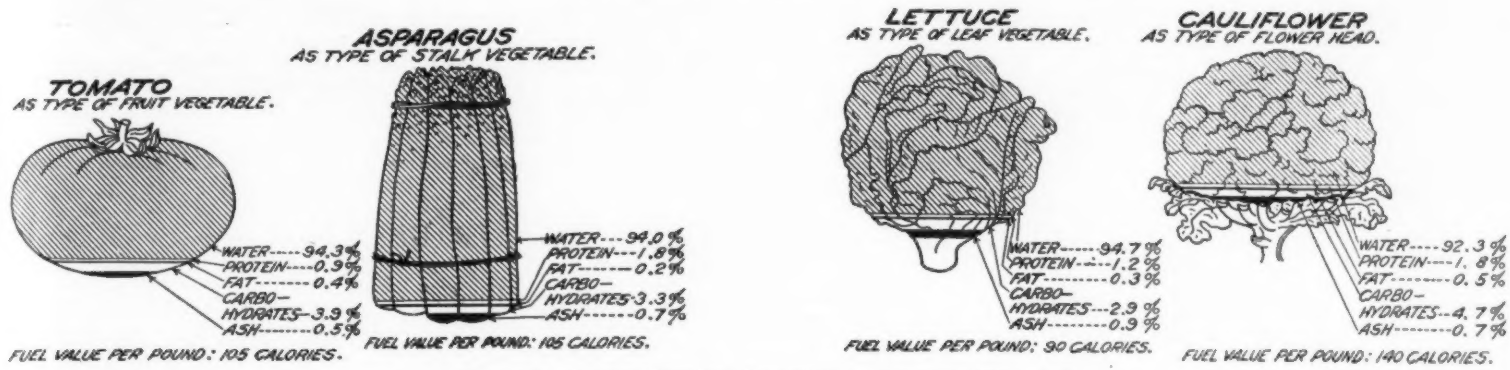
Of all families of human-food plants the crucifers are perhaps the most largely represented—cabbage, kale, cauliflower, mustard belong in this group. The family

flavor, as it may be called, is due to the presence of sulphur compounds. The illustration reproduced on this page sufficiently shows, in a graphic way, the value of some of these plants as food. The problem of cooking cabbages without filling the house with the odor of their sulphurous compounds has not yet been completely and practically solved by the Department of Agriculture. This would indeed be a boon to the nation. But "very few of the problems of vegetable cookery have, in fact, been carefully studied by laboratory methods," we are told. One such problem which has been scientifically approached by the Department is that of cooking green vegetables with the minimum of loss of nutritive matter. In the experiments made, "it was found that when cabbage, which contains 7½ pounds of dry matter per 100 pounds of fresh, green substance, was cooked in water, one half of the mineral matter and over one third each of the carbohydrates and nitrogenous material present in the dry matter were dissolved out." The only suggested way of avoiding this loss is to cook meat with the cabbage, so as to present a possibility of using the water as food.

On the other hand, small as is the relative quantity of mineral matter in these vegetables, they possess the advantage of bringing to the body this and the other requisites of food in a very available form, so that very little of what is taken into the stomach goes to waste. Of the protein, 70 per cent is assimilated, together with over 90 per cent of the carbohydrates and over 80 per cent of the crude fiber. If the average man could assimilate the constituents of milk in like proportions, both vegetables and meat would cease to be sought after as food by those who are eager to get the maximum of nourishment at all costs.



The value of green vegetables as food is enormously enhanced by their efficiency in maintaining a healthy activity in the lower part of the digestive tract. This is done by such substances as the cellulose, which forms the solid framework of the leaf, stalk, seed vessel, or other portion of the plant, which are indigestible and yet not irritating. Besides, there are some solutions of mineral salts which have a laxative effect, and succulent vegetables are rich in these solutions. The bulletin does not present any analysis of these and the other hygienic properties of green vegetables, but is content with the old-fashioned, but sufficiently convincing, empiric argument from the prevalence of scurvy on board ship in the days when sea voyages were long, and seafarers were compelled to live for months without any vegetable diet, and the invariable relief which resulted from a supply of fresh vegetables.



Composition of Some Succulent Vegetables as Compared With Milk.

Hardening Liquid Fats by Hydrogenation

Solid Products from Oils

The hardening of oils and fats on an industrial scale is an accomplished fact. It was the candle-manufacturers who were the first to manifest interest in a proposed process for transforming the ordinary liquid fats or oils, or the fluid components of the more solid fats, into a hard, solid substance, such as could be used in their industry in the production, without considerable increase in cost, of a finer grade of candles than they had previously turned out.

That the manufacturers of artificial food fats, of margarine, butterine, etc., were likewise interested in a process that promised to greatly increase the stability of their product and remove one of the main obstacles to its production and sale in warm weather was likewise to be expected, especially if the article obtained were in no respect changed in wholesomeness and were improved in flavor. Manufacturers of soaps were equally desirous of seeing the perfection of some simple and practical process for the hardening of liquid fats, for a hard fat, in some form, is a fundamental constituent of most of their productions, notably the better kinds of toilet soaps, in which firmness of substance under all atmospheric conditions is essential, and in the raw hardened oils and fats they were promised a material not only of the right consistency, but entirely unobjectionable as regards odor, flavor, etc., which could not be said of some of the soaps in the production of which, by the ordinary methods, the cheaper grades of fats and oils were used.

The fats used as raw material in various industries are almost without exception of compounds of glycerine with liquid or more or less solid higher fatty acids. The density or hardness of the fat depends on the proportion in which the solid fatty acids are present and it is easy to see how any process that would increase this proportion, by transforming the hitherto liquid into solid constituents, would be of the highest importance and value to those industries which chiefly require the solid components, i. e., the manufacture of soap, candles and foods.

The earliest efforts to accomplish this purpose, says Prof. Dr. Holde in *Technische Rundschau*, were directed toward the splitting up of the fats by chemical processes, so that the liquid or semi-liquid constituents would be separated from the solid substances and the principal aim was to obtain as large a proportion of the latter as possible. In 1855 Frémy took out a patent on this process, relating to the use of concentrated sulphuric acid for splitting up the fats, then boiling or steaming the fats thus treated to effect their transformation into pure fatty acids, the sulphuric acid being eliminated. The fact that the solid fats thus obtained contained dark decomposition products and that, for finer purposes, their distillation was necessary to effect their purification, was a disadvantage, but this process, and revivifications of it, were for years the only available means, subsequent improvements enabling it to be used with fairly good results. But fats treated according to this process were not suitable for the manufacture of artificial food fats. In the first place, odor and flavor were against them, their melting point was too low to allow of their use in making artificial butter in warm weather, the use of chemicals in their production was an objection and finally the proportion of fluid fatty acid transformed was not large enough to make them profitable.

The importance of the process had in the meantime attracted the attention of scientists who, working along different lines, finally reached a solution of the problem. It was known that the fluid fats consisted of a combination of certain proportions of hydrogen with carbon and other substances, and scientific research evolved the fact that by obtaining the incorporation of further volumes of hydrogen, the desired transformation from a fluid to a solid condition, could be effected. Thus oleic acid, the important component of many non-drying fluid fats, required the addition, to 282 parts by weight, of but two parts by weight of hydrogen to obtain from it stearic acid with a melting point of 69.5°C.

To effect, in the easiest manner, the incorporation with the acid of the additional volume of hydrogen, was the next objective, and here W. Normann made the most important departure, by employing catalytic action, that mysterious power of causing decomposition and new combinations possessed by certain substances that do not of themselves enter into the reaction.

To produce the catalytic effect Normann employed very finely divided metals, such as nickel, copper, etc., which, in highly heated fluid fatty acids, in the presence of hydrogen and under pressure, caused the conversion of oleic acid into solid stearic acid and of the fat glycerides into solid stearine.

The first patent on the new process was issued in 1902 by the German patent office to Leprince and Sieveke who sold their rights to the English firm of Crosfield & Sons a few years ago.

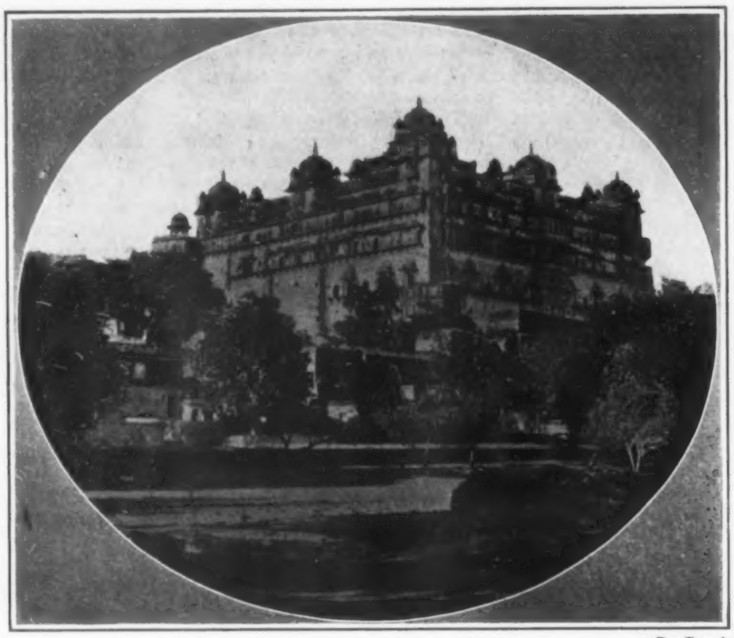
Other patents have since been taken out on processes and apparatus, notably by Hemptinne of Ghent, who sought, by means of electric glow discharges to incorporate hydrogen with oleic acid and did succeed in perfecting a process, whereby highly viscous oils, for lubricating oils of low viscosity; by Böhringer & Sons, who depended on the electrolytic reduction of oleic acid into stearic acid by the employment of metallic electrodes, coated with a spongy layer of the same material, palladium, platinum, etc., being thus used; by Willstätter, who used platinum and palladium in place of nickel as the catalyzer, by Paal, who used colloidal platinum in connection with lysalbinate and protalbinate of alkali as protective colloids and reduced castor oil, olive oil and fish oil to hard white crystalline substances. But the original Normann catalyzer process remained the basic patent, and when, about two years ago, this patent was bought by the aforesaid wealthy English firm, who also acquired many of the most important and practical apparatus patents, they controlled the situation.

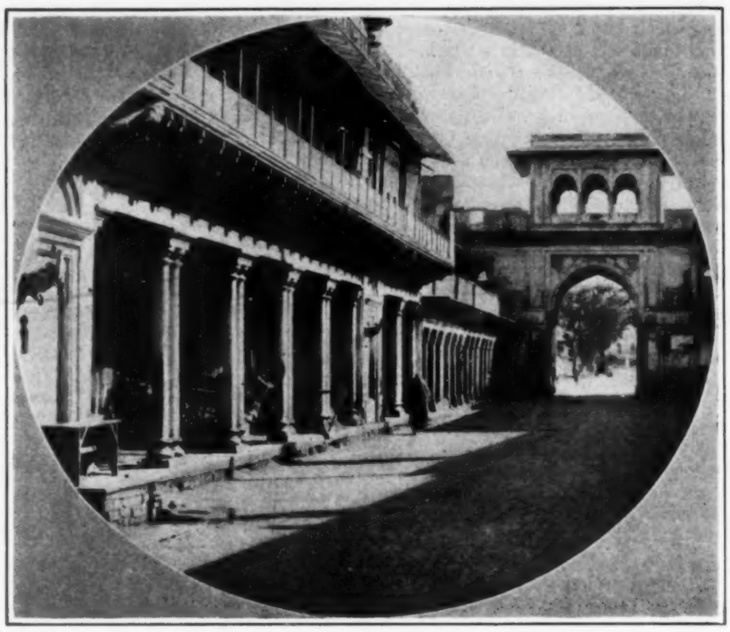
At Emmerich-on-the-Rhine, a strong German corporation, the Germania Oelwerke, under license from the English company, have a large and well equipped plant for the manufacturing of hardened oils and their output, Talgöl, Talgöl Extra and Candelite, are recognized as staple products of great excellence in Germany and are extensively used for soap and candle making, the production of artificial food fats, etc.

Improvements on the Normann patents have not been lacking and are in some instances eminently successful, although still as a rule tributary to the owners of the Normann patents. Thus E. Erdmann of Halle, obtained a patent on a process in which the hydrogen, on the counter current principle, works on the fatty acid flowing against it in atomized form from above, while the reaction product, constantly carried off, is removed from destructive decomposition. Bedford Williams employs 0.5 to 1 per cent of nickel oxide as a catalyzer and working under ordinary pressure at 225 deg. Cent. obtained excellent results; formate and lactate of nickel have also been used by Wimmer and Higgins.

Underlying all these improvements, however, is the original Normann patent on the use of catalyzers, on the owners of which nearly all the processes depend.

Under these circumstances and considering the expense of installing and operating a plant, especially the hydrogen producing part of it (although this might be obviated by the purchase of ready-made gas in compressed form) it is not likely that independent oil hydrogenating plants, owned and operated by manufacturers of soaps, candles and artificial food fats will, for a time, prove profitable, owing to the considerable first cost, especially in view of the excellent article placed on the market by the present manufacturers and the fact that the expiration of some of the existing patents may, in a few years, throw the business open to competition.





By Courtesy of Sphere.

The Possibilities of Indian Architecture. A Seventeenth Century Example.

This Comparatively Modern Structure Shows Plain Marks of Western Influence.

Delhi, the Metropolis of India*

How Shall the New Indian Capital Be Built?

By Sir Bradford Leslie, K.C.I.E.

*[A little over a year ago it was announced that the seat of government of India was to be transferred from Calcutta to the ancient capital, Delhi. The site originally proposed for the official center of the capital has been found unsuitable, and the site selected according to the present plans is that shown by a circle in the map on page 74. There has been considerable discussion regarding the best site for the city, and a very original plan has been suggested by Sir Bradford Leslie, whose address before the Royal Society is here reproduced. Sir Bradford's plan is interesting in many respects, but it does not appear likely that it will be followed.—*EDITOR*].*

IT is just twelve months ago since His Majesty the King-Emperor, from his Court at Delhi, proclaimed that city as the capital of the Indian Empire.

The following observations are intended to give a brief descriptive outline of a plan for giving effect to the proclamation of His Majesty, which plan, it is submitted, combines such manifold advantages that it should receive careful detailed investigation before any considerable outlay is incurred in the adoption of any other.

Plague and fever are endemic at Delhi. From the latest official returns Delhi heads the list of mortality from all causes, among the four largest towns of the Punjab; and from the annual report of the Sanitary Department it appears that the incidence of plague in the Punjab is seven times greater than in Bengal.

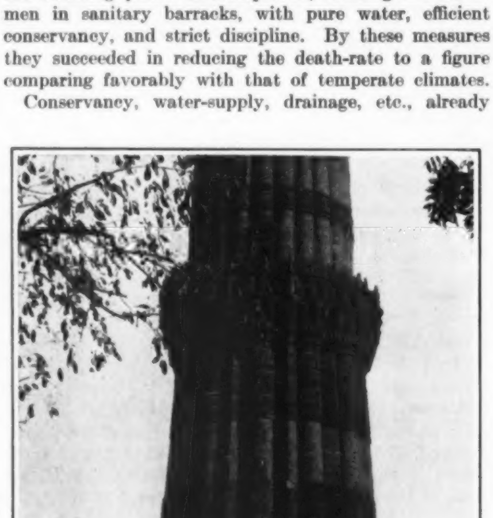
Plague is a disease of dirt. It is remarkable that its incidence is much less at cities such as Benares, Patna, and Calcutta, situated on perennially flowing rivers, which afford the inhabitants the luxury of bathing in the open air. At Delhi the flow of the Jumna is so reduced in the dry season that it is but little resorted to for personal ablutions. This accounts for the greater prevalence of plague in the Punjab, and at Delhi in particular, than in the Eastern Provinces.

The climate of Delhi is malarious, and fever is prevalent, especially in the cold season, because of the vicinity of the low-lying undrained bed or "Kadr" of the Jumna River, which, excepting for a slight fall from north to south, is dead flat, and as the flood waters subside becomes a malaria *nidus* of many square miles in extent. The prevalence of malaria is greater in years in which the winter rains are heavy, and less in years in which the winter rains, so beneficial for the crops, are deficient. Its duration also varies, but it never fails to take its deadly toll of the inhabitants of the Imperial city.

By the location of the seat of government at a new city three miles off to the south-west, and five miles from the foundation-stones laid by His Majesty, these unsanitary conditions will be avoided, but nothing is done to remedy the insalubrity of Delhi proper. Considering the improved knowledge of tropical hygiene and physical and material resources of the present day, it is submitted that measures should be taken to place Delhi at least on a par with Calcutta in point of salubrity.

When Col. Goethals and his staff undertook the construction of the Panama Canal they had a far worse problem to deal with. The climate was deadly. The death-roll in the days of de Lesseps from fever, dysentery, cholera, and drink was appalling. The American engineers realized that unless the workmen could be kept alive it was useless to attempt construction. With characteristic energy they put in practice the latest teachings of tropical hygiene, draining and sterilizing the breeding places of mosquitoes, locating the workmen in sanitary barracks, with pure water, efficient conservancy, and strict discipline. By these measures they succeeded in reducing the death-rate to a figure comparing favorably with that of temperate climates.

Conservancy, water-supply, drainage, etc., already receive attention in Delhi, but until the dry season swamps of the Jumna are dealt with, malaria will continue its ravages.



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The Kutub Minar. An Indian Monument Which Compares Favorably With the Finest Production of Western Art.

The present proposal is to convert the swampy dry season bed of the Jumna River into a lake by throwing a dam with an overfall weir across the river a short distance below the south or Delhi gate of the city. In the first instance, the height of the weir must be sufficient to cover the bed of the river with a sheet of water deep enough to float the dredging plant by means of which embankment and reclamation on both sides of the river would be effected.

Evaporation and absorption over the area of the lake would to some extent reduce the dry season discharge of the river.

The height of the weir should, therefore, be capable of adjustment by roller shutters so as to impound in the flood season a certain depth of water to provide for evaporation and absorption, and for supplementing in the dry season the discharge over the weir, convertible into electric energy. This arrangement would afford a valuable addition to the present dry season flow at the Okhla weir, eight miles farther down stream. The original borings taken at the site of the East Indian Railway Bridge at Selim-Gurh prove that a substratum of tenacious clay underlies the river-bed, and probably extends over the entire area of the proposed lake. If so, loss by absorption or percolation would be practically nil.

With the provision of suitable bathing ghats on the lake frontage of the city the opportunity and luxury of personal ablution, which experience has proved to be the best protection against plague, would be conferred on the inhabitants of Delhi, and no doubt they would appreciate the boon.

These measures would remedy the principal causes of the unhealthiness of Delhi. The river would at all seasons be a wide sheet of water, entirely suppressing the unsanitary "Kadr" valley.

Of course, the conservancy drainage and water-supply of Delhi proper must be brought up to date to complete the sanitary improvement of the city. Storm water would drain into the lake, but the sewage outfall would be below the dam into reservoirs treated on the septic system.

The site for the seat of government might then be on the civil station, but as the area available between the ridge and the river is somewhat circumscribed, it would be supplemented by about half a square mile reclaimed from the river by means of a stone-faced embankment extending from a short distance above Metcalfe House down to Selim-Gurh point. The land behind the embankment, being filled by dredging from the river-bed, would increase the area of the site of the new settlement to over two square miles, affording adequate accommodation for all departments. Space would be available to accommodate the Viceroy's body-guard to the north of Metcalfe House.

Above the railway bridge the permanent bank of the

* Abridged report of an address delivered before the Indian Section of the Society of Arts on December 12th, 1912, and published in its *Journal*.

river, that is, the margin of the "Kadr" valley, on the left or east side is irregular and ill-defined. Pending survey, the water frontage of the lake cannot on that side be exactly located. The water-level of the lake would vary by some six or eight feet. The slope of its bank must be at an inclination that would not expose a wide foreshore at low water. The formation of the slope would involve dredging, embankment, and leveling, and protection against wave action. The earthwork would be contoured with the greatest elevation at the lake side, such elevated bank being made wide enough for a broad road and for building sites. There would probably be a gradual fall inland to natural ground level. Storm-water would run off inland, and be drained into the lake by stoneware pipes or culverts. The formation would insure perfect drainage at all seasons.

The termination of the upper or north end of the lake would, of course, vary according to the water-level, extending higher up in the flood season and receding as the water-level gradually subsided in the dry season. In the absence of information as to the fall of the river-bed, the exact length of the lake cannot be exactly estimated. With a sufficient depth impounded in the flood season to provide for evaporation and absorption, the larger the area of the lake the more water will be impounded to supplement dry season flow available for electric energy.

The water-power developed at the weir available for the generation of electricity would, in the first instance, be used for dredging and reclamation, and subsequently for lighting the city at night and working tramways by day, and other purposes.

In the monsoon there will always be a super-abundant supply of water-power. By the formation of suitable land by banks and tanks these districts have become normally healthy.

I know of no instances where the proximity of reservoirs, lakes, or other sheets of water has injuriously affected the climate.

At a comparatively small extra cost the proposed weir and dam across the river can be made to carry a line of railway, forming part of a railway about eighteen miles long between the Oudh and Rohilkund Railway at Ghazeebabad and the Southern Punjab Railway at Shakurpur, avoiding the congested Delhi central station, and connecting with the Agra Delhi Chord near Pahargunge. Such an avoiding line is necessary to accommodate traffic between the Oudh and Rohilkund Railway and the North-Western State Railway. It would also afford an alternative connection between the United Provinces and the capital of India, and South Punjab and the irrigation colonies, in case of accident to the Selim-Gurh Bridge.

The route of this railway will traverse about half a mile of high rocky ground to the southwest of Delhi proper by a deep cutting. The rock excavated will be used for the weir and the reclamation. Such being the case, the cost of excavation would be divided between the railway and the weir and reclamation, saving 50 per cent to each.

It will be objected that these works will take a long time to carry out and be very costly. Hurry is to be deprecated. "Rome was not built in a day," and India's new capital, wherever it is built, will not spring up like a mushroom. Patient and intelligent study will be required for the best and most economical solution of the problems that will present themselves to the engineer. No accurate estimate is possible until surveys have been made and plans prepared, with complete tables of quantities of work of every description. The maximum difference between the level of the lowest water in the dry season and the highest in the floods is 12 feet. Delhi is well above the highest floods, and to provide for evaporation, the height of the crest of the weir may be a few feet above flood level, but at the maximum the head of water to be held up by the weir will not exceed 16 feet, probably less, and I apprehend that there will be no danger of blowing. There is great engineering experience in the construction of weirs across the Jumna and Ganges. With an abundant supply of stone at half price, as previously explained, the cost of the weir should not be a very formidable item. The bed of the river to be dredged to fill in the area to be reclaimed on the west, and to raise the banks of the lake on the east side, is sand. With modern dredging and transporting plant, the overall cost of dredging and depositing on the banks of the lake, up to an elevation of 30 feet, would be one shilling a cube yard. The total cost of reclamation and weir might be one million sterling. In such work expedition is synonymous with economy; and if the work were let by contract it should certainly be completed in three years.

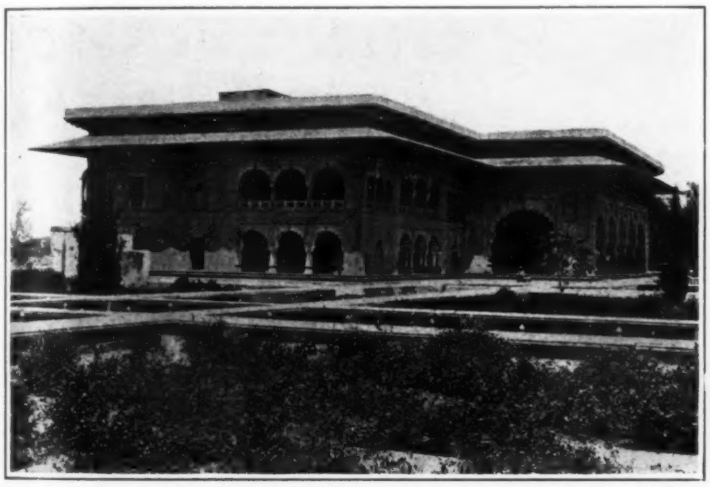
The reclamation of the water frontage on the east or left bank of the lake, which may be some six or more miles in length, has already been described. Part of this frontage might be used for the large colony of subordinate Indian employees of government. The permanent home of the majority of these men is Calcutta, but under the changed conditions it will be necessary to make provision for their families at Delhi. At present most of them live on ground reclaimed from paddy fields by the excavation of tanks, and could well be housed on the elevated belt of land adjoining the lake, where they would enjoy the advantage of daily open-air bathing, which to the Bengalee is almost a necessity of existence. They would be ferried across the lake daily to and from the official city in covered motor-launches, for which piers would be built. Also a bazaar and bathing ghats and schools should be provided. The Hindus would probably build their own temples, and the Moslems a musjid. The remainder of the water frontage on the east side of the lake could be laid out as a park, or otherwise utilized. Excepting for storm water, drainage into the lake would be strictly prohibited.

The Mazagon-Sewree reclamation of the Bombay Port Trust, and the Immingham Dock on the Humber River, where millions of cubic yards of dredging and reclamation have been done at very low cost, are recent instances of the perfection to which such plant has been brought.

Consequently the cost would be minimized, and the site value of the land reclaimed, at urban rates, will, in all probability, more than cover the cost of reclamation.

Part of the cost of the weir and dam would be borne by the Oudh and Rohilkund and Southern Punjab Junction Railways referred to above, and the value of the electric lighting and tramcar services worked by the power developed at the weir would cover interest on the balance. The outlay would, therefore, be remunerative.

The water frontage of the reclaimed area on the right (or west) side of the lake, about two and a half miles long, would be laid out as a wide boulevard, with, in the first instance, light buildings only on the land side thereof; but, after a couple of years' consolidation, the heaviest buildings on platforms of reinforced concrete would stand securely on the reclaimed area. Such a boulevard should be for the accommodation of pedestrians and passenger vehicles only. For dealing with goods or building material, removal of trade refuse and conservancy, a back thoroughfare should be provided, giving access to the rear of all premises on the boulevard. I mention this detail here so that it may not be forgotten when London builds its main central boulevard. The congestion of London street traffic is chiefly caused by the obstruction of delivery carts blocking the thoroughfare.



By Courtesy of Sphere.

Examples of Modern Indian Architecture. It is Urged That Native Art Should Figure in the Buildings of the New Capital.

drains and sluices and the provision of centrifugal pumps, such water-power may be used for draining the Durbar area, so that the salubrity of the seat of government will no be imperilled by the vicinity of a swamp, and at all seasons of the year the area will be a healthful well-drained place of recreation, available for golf, cricket, aerodrome, racecourse, and for the exercise and review of troops, and valuable for pasturage or cultivation.

It is said that the town planners have been cautioned to "beware of water."

In Eastern Bengal the rice grows in water six or eight feet deep with straw eighteen feet long. A dense population thrives and multiplies in villages perched on islands in the midst of inundated rice-fields extending as far as the eye can see. The rainy season, when the inhabitants go to market in their boats, is the healthiest of the year. When the water is drying off the land, and weeds decay, there is some malaria. Even the retting of jute over large areas, except in so far as it pollutes the drinking water, is not insalubrious.

In the dry season the former deserted beds of the Ganges and other rivers form extensive lakes, and snipe jheels, swarming with fish, wild-fowl, pelican, and water-lilies, are beautiful sheets of water, and even these are not malarious, and I wish I could be back there now.

In Central India and Madras innumerable large tanks or reservoirs, often in chains one below the other, irrigate the land. So long as these, replenished by seasonable rainfall, are water areas, the health of the people is good. It is only when the rains fail and silted-up tanks are allowed to become shallow swamps that they are insalubrious.

The Jubbulpore Branch and Chord lines of the East Indian Railway when first made were sparsely inhabited, and very malarious. As cultivation has extended and water for irrigation has been kept on the

The training embankment reclaiming a sufficient width for extension of the boulevard from Selim-Gurh down to the weir would be a great improvement to Delhi proper, but not being immediately necessary it might be reserved for the future.

The new capital thus outlined would be contiguous to, and an integral part of, Delhi proper. It would be served by the existing central station, and would not require the construction of a special branch railway to connect it with the outer world.

It may be that the "Kadr" of the Jumna in the dry season is valuable for cultivation and pasture. Any value it may have in that respect will be more than compensated by licenses for fishing in the lake. By proper stocking, the lake can be made to produce an enormous supply of rui, hilsa, and other fish, and snipe and teal will be plentiful in the jheels higher up the river beyond where the lake terminates.

To whatever extent masonry may be used for architectural adornment of the capital, brickwork or concrete made of bricks must be the principal structural material of the city; bricks or brick concrete must also be the foundation of all main thoroughfares and the material of sewers. Bricks must be burnt in millions. Economy of transport generally requires that the brickfields should be near the site of the buildings if suitable brick earth is available, but it is objectionable to have the suburbs of a large city cut up by brick pits. It is probable that cheap brickfields can be acquired at or near the head of the lake, whence all the bricks could

be boated down and delivered on either side thereof, close to the sites at which they would be used. This would effect a very great economy in the cost of the main item of building material and keep the brick-fields quite remote from the city.

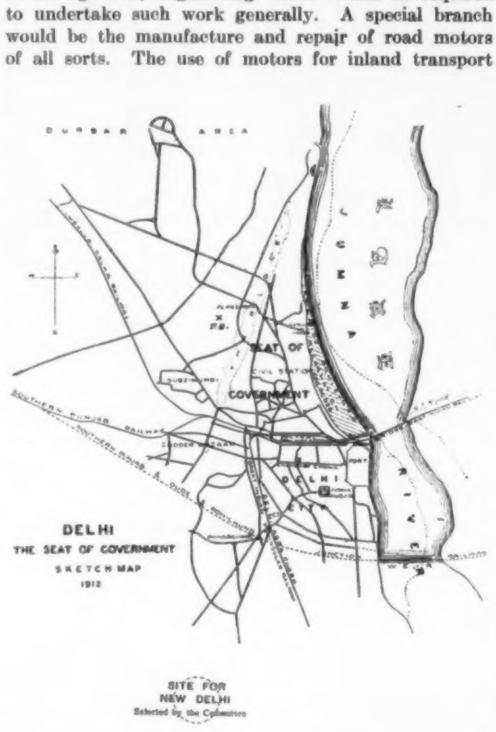
When the lake is formed and the "Durbar area" drained, as described above, the climate of Delhi will become normally healthy. After the beginning of September the heat rapidly abates in the Punjab. The climate becomes delightful, and continues so until the end of March, seven months of the year.

Without the navigation weirs, the upper Thames would, in the dry season, be but a small and insignificant stream, with pools here and there, and shallows elsewhere. By the weirs the waters of the stream are retained and the river is divided into a series of reaches of surpassing beauty, affording enjoyment to thousands of London's citizens and visitors. The present proposal is to treat a single reach of the Jumna in the same manner as the Thames, primarily to suppress an unsanitary swamp, but in addition to accomplishing this it will result in the formation of a beautiful lake, surely not an extravagant idea to adorn the capital of India.

The situation of Delhi, equidistant by rail from Bombay, Karachi, and Calcutta, has already made it the most important commercial *entrepot* of Northern India for the distribution of imported goods, hardware, piece-goods, etc., and this pre-eminence must increase when it becomes the permanent home of the Indian Government Colony, the numerous Indian employees of government and their families. The industrial development of Delhi has hitherto been seriously handicapped by the high cost of coal, over $5 per ton. Notwithstanding this, there are in Delhi some twenty factories with their own power plants varying from small sizes up to 500 horse-power. The cost per unit of power, whether produced by steam, oil, or gas generating plant, is unavoidably greater than in Calcutta or Bombay. Water-power developed by the weir converted into electric energy will be a cheap source of power. The Jumna being a glacier-fed stream, its flow in the season of the melting of the snow will replenish the lake annually even if the monsoon should fail. Obviously, therefore, the design of the weir should be such as to impound as much water as possible in the rainy season. The data for calculating the extent of this source of power are not available, but the Jumna Power Project, with three or four hydro-electric generating stations on the upper course of the river, will develop some 50,000 horse-power, which, at high voltage, can be transmitted to Delhi, insuring a cheap and reliable source of power, which will enable factories of any description to be established in the vicinity of the city.

Delhi is conveniently situated for a central depot, both for standard and meter gage rolling-stock, which might be located near Shakurpur; there are no repair shops nearer than Lahore or Allahabad. Workshops for the manufacture and repair of rolling-stock at Delhi would save empty running, and before they can be built will have become indispensable to relieve the pressure at existing workshops, where repairs of stock are always in arrears. Such workshops fully equipped with the newest type of machinery, driven by cheap electric energy, would, by keeping rolling-stock on its legs, greatly contribute to relieve the shortage of wagon supply, which constantly cripples the working of Indian railways.

Besides workshops for the manufacture and repair of rolling-stock, engineering works would be required to undertake such work generally. A special branch would be the manufacture and repair of road motors of all sorts. The use of motors for inland transport



of every description is bound to increase rapidly; many outlying towns or groups of towns, not sufficiently important for branch railways, may be served by motor vehicles. Indian potentates, rajas, and others are realizing the luxury and convenience of motor traveling, and all who can afford to do so will possess motors. Such vehicles must be kept in repair, and owners will save time and money by getting the work done at Delhi instead of sending their cars to Bombay or Calcutta. Rubber works for working up scrap tires with new rubber, and leather works for making the coverings and cushions of car bodies, will all be wanted at Delhi; also presses for vegetable oils, and paint and varnish factories, besides textile and woolen factories, are certain to be established. These, with work for local municipalities, will keep the engineering workshops busy.

Trade follows in the footsteps of commerce and manufactures. Stores, shops, showrooms, and agencies for the display and sale of goods of all nations will be established, and where people congregate entertainments and amusements will be provided, making Delhi the true Indo-European metropolis. When the direct narrow-gage railway from Saharanpur *via* the Mohun Pass is made to Mussoorie and Landour, these hill-stations will be within twelve hours of Delhi.

Indian cities with civil stations and cantonments and a few general shops are distributed over India, but, except perhaps at the sea-ports, there are no Indo-European cities, which may explain the reason why an Indo-European style of architecture has never been evolved. Much discussion has taken place as to the style of architecture to be adopted for the government official city of Delhi. A uniform style of architecture, especially if the work of one man, must be monotonous, and, unless the architect is a great genius, cannot fail to be depressing. Variety in ideas and inspiration relieve the sordid uninteresting impression which would be the inevitable result of a hard-and-fast rule as to style to be adopted.

The residence of the superior government officials there will be intermittent; it is, therefore, probable that hotel or club life may suit many of them better than setting up private establishments. Such buildings as hotels and clubs may well be palatial, but it is to be hoped that the builders will study first the convenience of dwellers therein, and subordinate to this, ambitious attempts at architectural effect, recent examples of which in London have not been too happy. In tropical regions buildings must be spacious and lofty; social amenity demands that civic architecture shall be in some degree ornamental. Ordinary methods of construction, without steel framework, will continue to be used in less important houses and private residences.

In such climates it is usual, it may be said necessary, to protect the walls from the sun by verandas supported on pillars or corbels, with broad cornices at roof level. Such cornices, balconies, or pillared verandas are more suitably treated by Indian design than by any exotic type of architecture.

The perforated stonework, brought to rare perfection by native craftsmen in providing screened balconies for Indian ladies, is eminently suited for substitution for the wooden louvers generally used to exclude the sun and admit the air. With the steel framework for giving stability to the main building, such external features as verandas, etc., can be built in stone not overloaded with superfluous ornament, but dependent for architectural effect on symmetry and well-proportioned general features, and judicious use of decorative structural detail. Such a style of art suited to the climate and the modern system of construction cannot be renaissance. It may be a new style, "Indo-European."

Micro-Organisms of the Soil*

Co-operation of Biologist, Chemist and Physicist Needed in the Study of This Subject

By George T. Moore

SUCH statements as "the soil is not a mere sponge, but is teeming with life" or that "the earth is one of nature's vast laboratories in which microscopical wonder-workers perform incredible experiments" may have been unusual enough at one time to attract attention; but no longer is the presence or performances of these inhabitants of the soil of such novelty as to startle or dismay us. Indeed, so accustomed have we become to the idea that each gramme of the upper layers of the earth is filled with its millions or billions of bacteria, that the tendency is to ascribe all functions of the soil to its micro-flora and no theory is too bizarre, no miracle too improbable, so long as we may fall back upon the soil bacteria to account for it.

Fischer, you will remember, after a more or less critical review of the situation, came to the conclusion that we do not now possess a method of bacteriological examination of soils, which is of the least practical value. While not subscribing to this view, it must be confessed that a study of the literature on the subject indicates that much of fundamental importance remains to be done before we can hope that an investigation of the microorganisms of the soil will result in really solving some of the perplexing problems of fertility now confronting us. Even the nomenclature of the subject is so indefinite at the present time, that within the past year we have had conflicting uses of such familiar terms as "nitrification" and "nitrogen fixing" and there certainly is need for some such unification and strict definition of terms as that suggested by Lipman.

There is also considerable evidence that we have been so obsessed by the pure culture idea, that conclusions drawn from experiments performed under such conditions are entirely unwarranted. If it is true that mixed cultures of *Azotobacter chroococcum* and *Pseudomonas radicicola* will fix almost twice as much nitrogen as either alone, to say nothing of the necessary interaction between various groups in making available green manures, phosphoric acid, lime nitrogen, etc., it is very evident that conclusions drawn from the study of a single organism can not be applied to the conditions actually existing in the soil. We might as well assume that a superior being, dipping down into our atmosphere and selecting a single individual, would be able to arrive at the various functions and activities of man on the face of the globe, by observing his behavior under such artificial conditions as it would be possible to maintain in a heavenly laboratory. It is neither necessary, nor advisable, of course, that we abandon the pure culture method. But we should recognize the limitations of our present technique and cease to generalize from such inadequate data.

Not only are standardization of methods and interpretation of results, as well as a still further recognition of the effect of various groups of bacteria, one upon the other, much to be desired; but an appreciation of the fact that something else than the bacteria go to make up the microscopical life of the soil, must be more generally taken into consideration, in our attempts to find out what actually goes on in the ground. It must be confessed that thus far any knowledge of the algal, fungal or protozoal inhabitants of the soil has tended to confuse rather than clarify any conclusions regarding the phenomena induced by a single group of organisms.

Perhaps no better example of the chaotic condition of the present status of the microbiology of the soil can be cited than in the recent revival of a consideration of the effect of heat and various so-called antiseptics on crop production, and the supposed relations of protozoa to the problem. That the addition to soil of carbon bisulphide, toluol, ether and similar agents, will *under certain conditions* benefit *some* crops, has of course been known for nearly twenty years, and as early as 1888 Frank believed that sterilizing soil with steam increased the solubility, or availability, of mineral and organic substances.

Various theories, from the mere removal of superabundant, though harmless, bacteria, to the destruction of toxins, have been proposed to account for this beneficial effect, but it remained for Russell and Hutchinson, of the Rothamsted Station, to stimulate interest in the subject. These investigators, in October, 1909, an-

* Presented at the Symposium on Soils at the Washington meeting of the American Association for the Advancement of Science.

nounced that they had found the increased productiveness of partially sterilized soil to be due to an excess of ammonia, arising as a result of the bacterial decomposition of soil substances, these bacteria being able to multiply enormously on account of the removal, by heat or volatile substances, of large protozoa which normally feed upon the bacteria. This announcement was hailed both in this country and abroad as the greatest discovery pertaining to the soil, since Hellriegel's interpretation of the beneficial effect of bacteria in the root-nodules of legumes!

A student in my laboratory becoming interested in the problem, undertook a considerable number of preliminary experiments, the results of which seemed to warrant a more elaborate investigation into the effect of soil sterilization upon crop production. It is not necessary to go into details at this time, but laboratory, greenhouse and field tests all indicated most decidedly that the theory of Russell and Hutchinson is *not* of universal application, and the importance of the protozoa, so far as their effect upon bacteria is concerned, has been overestimated. It is true that Russell and Hutchinson themselves considered the removal of the protozoa as being but one factor concerned in the benefits accruing to plants, by the use of antiseptics, and it may be that the prominence given to this aspect of their work is due to the advertising propensities of those not immediately concerned with the investigations. This is unfortunately sometimes the case. The fact remains, however, that in many of the comments published by those rather closely associated with Russell and Hutchinson, the effect of antiseptics upon protozoa is deemed to be the only one worth considering, and to which all resulting benefit is due.

Within the last few months, several papers have appeared which likewise fail to agree with Russell's and Hutchinson's results. Goodey, publishing in the *Proceedings of the Royal Society*, shows that at least one important group of protozoa, micro photographs of which have been used most extensively to illustrate popular articles on the subjects, can have no part whatever in disposing of beneficial bateria or influencing in any appreciable way the fertility of the soil. For it is found that the ciliated protozoa which are so characteristic a feature of cultures made from soil, exist only in the encysted stage in natural soil conditions. There remain, of course, the amœbæ and flagellates, about the condition of which in soil we are not certain as yet. But the fact that all of these organisms are able, within a short time after being removed by disinfectants, to re-establish themselves in soils, would seem to indicate that even though they might have some direct effect upon the bacterial content of the soil, the removal is so transient that the effect on crop production is negligible. This is no place for figures, but if it were I could show as the result of tests, extending over a wide field, that the number of protozoa, including flagellates, ciliates and rhizopods, existing in the soil three days after treatment with various percents of toluol, carbon bisulphide, etc., may equal or even exceed the number originally present.

Koch and Fred at the Agricultural Institute of the University of Göttingen, since the appearance of Goodey's paper, have each published independently upon the effect of ether and carbon bisulphide on lower and higher plants and conclude that for both the microflora of the soil and the crop it bears, the beneficial effect is purely stimulative—simply the old idea of all poisons being beneficial to growth if sufficiently dilute.

Greig-Smith, in spite of the apparent refutation of the toxin theory of Russell and Hutchinson, returns to it as affording the best explanation of the observed results. He claims to have extracted from soil a substance which is filterable through porcelain and which is toxic to bacteria. This toxin thus retards the growth of higher plants by the destruction of beneficial bacteria, but in turn is destroyed by the application of heat or volatile antiseptics. An additional effect of these agents is upon the so-called "agricere," which, according to Greig-Smith, is a mixture of saponifiable and unsaponifiable bodies, coating or waterproofing particles of soil. When heat or certain wax solvents are added to the soil, they alter the distribution of the earth wax, carrying it to the surface and causing it to segregate on the points of the soil particles. The beneficial effect of the removal of the waterproof covering is of course that the constituents of the soil are more easily attacked by the bacteria and rendered available for plant nutrition.

Bottomly, before the British Association this summer, confirmed to a certain extent the work of Greig-Smith by demonstrating the injurious effect of the "bacteriotoxines" upon the germination of seeds and their subsequent growth, the harmfulness of which could be prevented by first heating the soil.

Without further reference to contradictory results obtained by various investigators since the announcement of Russell and Hutchinson, experiments in my own laboratory indicate that the matter is probably incapable of being satisfactorily explained by any of the single factors which have been suggested. The one fact which does seem to be fairly well established is that the temporary removal from the soil of the protozoa has but little bearing on the problem. Neither is it by any means certain that the use of heat or antiseptics is universally favorable to all crops on all kinds of soil and it seems probable that the character of the soil, as well as the kind of crop, will have to be taken into consideration before we can have a true explanation of why some crops are benefited by the so-called sterilization of some soils.

Aside from a very few pathogenic forms, but little is specifically known of the fungus flora of the earth. That fungi may be as abundant as the bacteria, particularly in uncultivated soils and that below the humus-containing layer, they may considerably exceed the bacteria, has been ascertained by a few analyses. But what they do and how they do it, is for the most part a matter of conjecture. To those familiar with the rapidity and certainty with which some of the higher fungi reduce organic to inorganic matter, it is evident that there is no group of organisms present in the soil that would seem to be more capable of producing profound changes in its environment. Not only do we know that a considerable amount of the decay in animal and vegetable tissue, particularly the early stages, is due to the higher fungi, but the work of Czapek and Kohn, showing that *Penicillium* and *Aspergillus* when supplied with ammonium chloride set free hydrochloric acid, as well as the demonstration of the production of an organic acid in *Penicillium* by Alsberg and Black, points to still further possibilities by plants belonging to the same, or closely related groups.

Formerly it was supposed that the number of plants whose roots entered into combination with some fungus —presumably for mutual benefit—was limited and confined to but few families. Now it is estimated that about one half of the seed plants possess within their roots some mycorhizal organism and in many notable instances the plant is unable to thrive under natural conditions without its particular fungus. Furthermore, as has been pointed out by Coville, the acidity factor in the distribution of some plants is mycological rather than purely chemical.

Our knowledge of the effect of soil fungi upon the germination of seed is also being extended. Barnard has recently shown that seed of both the common potato and *Solanum dulcamara* fail to germinate in the absence of their mycorhizal parasite, while 40 to 90 per cent begin to grow in the presence of this fungus.

Whether the considerable number of wild yeast-like organisms occurring abundantly in many soils, are capable of producing profound changes in their habita is still problematical. That certain of these may fix atmospheric nitrogen in the laboratory seems to have been demonstrated, and it appears reasonable that should conditions in the earth be favorable, we might expect yeasts to have a decided effect either upon the soil or its inhabitants. Despite the necessity of yeasts having secondary breeding places, such as aqueous extracts from fruits and other vegetable matter, the soil must be considered the chief abode of these fungi, and not only during the colder months, but throughout the entire year.

Even less is known about the algal content of the soil than of its fungus constituents. The older literature is full of references to the nitrogen-fixing power of both grass-greens and blue-greens, but it is a striking fact that since the introduction of the pure culture method for algæ, there has been no authenticated demonstration of the power of these plants to add in the slightest degree to our store of fixed nitrogen. It is true that Heinze working with impure cultures of *Nostoc* thought he had demonstrated by a process of elimination its ability to fix nitrogen. Since *Azotobacter* was not present and the fungus in the culture could not by itself fix nitrogen, he assumed that the nitrogen accumulated must be due to the alga. But this can hardly be accepted as conclusive. While it is possible that some of the blue-greens may have this power, it is not likely that they are of much importance and there is need of a most careful investigation of the whole subject, now fortunately under way, before we can be at all certain of what the algæ alone accomplish in the soil.

The possible beneficial relationship between the algæ and the bacteria is quite another question. I believe it is not widely known that quite independent of any surface growth of algæ, there exists in the lower layers of the soil an algal flora which in some localities, at least, is equal, bulk for bulk, to the bacterial flora. Exact quantitative estimates are difficult and in the incomplete state of the work, only approximations can be made, but it is safe to say that under some circumstances the individual algal cells, many times larger, of course, than ordinary bacteria, number between three and four million per gramme of soil. For the most part these cells belong either to *Anabæna* or *Nostoc*, and without committing myself at this time to the original observations of Brand, recently confirmed by Miss Spratt, that the heterocyst of *Nostoc* and *Anabæna* gives rise to gonidia-like spores, I may say that heterocysts obtained from the deeper layers of the soil often show the contents divided in precisely the way figured by Brand and Miss Spratt. If it be true that the heterocyst is capable of giving rise to spores, it would account, of course, for the large number of isolated cells found in the soil, and further explain how there may be such an abundant algal flora below the surface, which, be it noted, is totally different, as to genera, from the surface film of algæ.

The observations relative to the fixation of atmospheric nitrogen through the association of algæ and bacteria are somewhat more satisfactory than those dealing with algæ alone. We have some experimental evidence for believing that when certain nitrogen-fixing bacteria are growing with some of the blue-green algæ, the amount of nitrogen exceeds considerably that fixed by the bacteria alone and the benefit of the combination upon growing crops is marked. Thus we have an additional complication in dealing with the vital activities of the soil, for it appears we must not only consider the interrelationships between various groups of bacteria in so-called "mixed culture," but the influence of a considerable algal flora must also be taken into account.

No discussion of the microorganisms of the soil would be complete without some reference to the nodule-forming bacteria of legumes. That the practical application of our knowledge of the effect of these, usually, but not always, beneficial bacteria must be demonstrated in the field, rather than the laboratory, goes without saying. However, it is hard to understand how we may hope to gain much definite information either as to the needs or activities of these bacteria, when conclusions regarding them are drawn exclusively from such an inconstant and uncertain source. That much depends upon the virulence of the particular strain of organism is evident and the use of nitrogen-free media, first suggested in this country and some modification of which has since been widely adopted, both at home and abroad, has resulted in increasing materially the percentage of successful inoculations. Whether the conflicting results obtained by different investigators can be harmonized, in the state of our present knowledge, is doubtful, for the conditions are bound to be so various and the bacteria themselves so sensitive to changed environment, that comparable results will seldom be obtained. Indeed, it may not be impossible that *Pseudomonas radicicola* plays a more important rôle outside of the root nodules than within it, and instead of attempting to induce the legume organism to form nodules on other crops, we should perhaps be paying more attention to the organism as it exists in the soil, independent of the roots of any plant.

In this connection, however, I may say that I now have under cultivation an organism capable of fixing nitrogen within nodules comparable in every way to those found on the legumes, but growing on a family far removed from the Leguminosæ, namely, the Aristolociaceæ.

Of the importance of the bacterial flora in rendering available, to higher plants, the various necessary mineral constituents of the soil, little need be said. That a large number of organisms are able to influence the potash, lime, magnesia, phosphorus and other minerals of the soil solution is well known. It even appears that calcium salts of various organic acids, frequently formed by plants and occurring in soils, may be oxidized to carbonates by a considerable variety of bacteria, thus conserving the lime supply to the last degree. On the other hand, it may be well to point out that the generally accepted theory regarding the action of the so-called iron-bateria is probably incorrect. Winogradsky's hypothesis, that the soluble bicarbonate in water or soil was absorbed by the organism and, as a result, of cell metabolism, changed into ferric hydroxide, was never proved, even by its author. The analogy between the appearance of iron on the walls of these forms and the oxidation processes of the sulphur and nitrate bacteria seems to have been the chief reason for its promulgation. Molisch has shown that iron is not necessary for the growth of these organisms and later other investigators proved that manganese readily replaced the iron. There seems to be no reason, therefore, for assuming that the deposition is in any way connected directly with the metabolism of the plant. Rather is the relationship similar to that existing in certain algæ and an aquatic ascomycete, recently obtained by me. Klebs showed that *Zygnema* could retain in the gelatinous layer surrounding it, not only iron, but aluminium and chromium compounds. Whether this is due to some pecularity in the wall, or reversed chemotaxis, with the plant attracting the metal, instead of the chemical attracting the plant, remains to be seen.

Without going further into details, I think enough has been said to indicate the diverse character, and yet the close inter-relationship, existing in the microbiological content of the soil. While it may not appear to simplify the problem, by admitting that the physiologist, the bacteriologist, the mycologist, the algologist and possibly the protozoologist, to say nothing of the chemist and physicist, must all co-operate before many fundamental problems involving fertility and plant nutrition are finally solved, I am inclined to think this is the only means whereby we can hope for success.

Fig. 1.—A Large Silk-cotton Tree Near Havana, Cuba.

Fig. 2.—Silk-cotton Thread, a Sock, a Crocket Fichu, and a Piece of Cloth With Cotton Warp and Silk-cotton Woof.

Fig. 3.—A Silk-cotton Tree (*Eriodendron anvractuosum*) in Cuba.

Silk-Cottons

Economic Products from Tropical Trees

Technical foresters frequently receive inquiries from brokers, importers and others as to the identification and the present and probable feature uses of the various silk cottons so plentiful in many parts of the tropics. A few brief statements, for convenient reference, in regard to the principal cotton-yielding trees may be of interest to the general reader as well as to users of these fibers. The silk cotton of a number of cotton-yielding species has been made economically useful on a commercial scale, and it is not at all improbable that the material of all such trees will eventually become useful in the textile industry. The cotton from some of these trees is very abundant and can be had at a relatively small cost.

The silky substance which is now gradually gaining prominence commercially is borne in the capsule or fruit of certain trees, and surrounds the seeds in a manner similar to that of our cotton plant. The fibers of some species are used as a substitute for cotton, and cost only about half the price. The fibers of other species are wanting in tenacity and have thus far been found generally unfit for the manufacture of any durable material. It is highly probable that it might be very advantageously used in combination with other substances, not merely for the purposes of upholstery, but even in the manufacture of mixed fabrics for various other uses in the arts. There is on exhibition in the Commercial Museum in Philadelphia a pair of stockings (Fig. 2) manufactured from the silky floss of the Ceiba or West Indian Silk-Cotton tree. These stockings are the result of West Indian skill in spinning and manufacturing.

The machinery used in spinning and weaving the ordinary cotton fiber is not adapted for utilizing this material owing to the shortness, weakness and elasticity of the staple, and the lack of adhesion between the fibers. In consequence of this, the bulk of the material lacks commercial importance except as employed for stuffing beds, pillows, cushions and sofas. For these purposes an enormous quantity is used annually in the United States.

Perhaps the most important cotton-yielding tree in the world is the Ceiba or West Indian Silk-Cotton (*Eriodendron anvractuosum D. C.*) (Figs. 1 and 3). The generic name *Eriodendron* is derived from two Greek words *erion*, wool, and *dendron*, tree, and was given to this tree because of the woolly substance which surrounds the seeds; the specific designation is from *amb*, a path or road, and *frango*, bending. It received this name on account of the enormous size of the trunk near the ground, which causes in some instances a marked deflection of roads. Old trees develop numerous enlarged spurs, wings or buttresses at the base. These spurs are sometimes more than two feet wide and only from two to four inches thick, and spread so extensively that in some instances a man walking around a tree must make a distance of 150 feet. It is the largest inhabitant in the West Indies, Mexico, and Central America; it is found also in tropical Africa, parts of India, Burma, and East Indies, and but a few trees have a loftier and more majestic appearance. The Ceiba attains a height of from 60 to 80 feet and develops enormous spreading horizontal branches. It is a tree that is present usually in all open plains and cultivated fields. Old specimens sometimes have enormous crowns that spread 150 feet, thus affording an ample crown for the development of cotton.

The silk-cotton which surrounds the seeds of this tree is the "floss" or "kapok" of commerce. It is exported in large quantities from the East Indies and West Africa; the variety from Java is regarded as a fiber of great merit, and is used for stuffing pillows and sofas. Its lightness, softness and elasticity renders it superior to the best qualities of feathers, wool, or hair. This material has been employed also as a buoyant material for packing life belts and for making hats and bonnets, and has even been suggested for the manufacture of paper and gun cotton. It is too short in staple and too weak to be spun into yarn. Unfortunately the silk-cotton from the West Indies is accounted of little value at present, but it only remains for some one to start its collection in Cuba and Jamaica and ship it to American markets. It has been estimated that the average yield of silk-cotton from a single tree in the West Indies and Mexico is approximately 100 pounds. Many thousands of bales of silk cotton might be collected annually in the West Indies and turned to economic use. In 1907 a little over 20,000,000 pounds of silk-cotton was exported from Java and Sumatra, and of this quantity about 3,000,000 pounds were consumed in the United States for a great variety of purposes.

Fig. 4.—The Barriguda Tree.

Sometimes the Ceiba tree is called the five-leaved Silk-Cotton to distinguish it from the Bombay Ceiba or Balsa (*Ochroma lagopus Sw.*), another tree common in the West Indies, which produces silk-cotton and has only three leaflets to each leaf stalk. This species which is especially abundant in Jamaica contains in its capsules fine, soft, white down, which closely enwraps the seeds and which is used in the manufacture of English beavers. The Balsa grows along the deep muddy shores throughout tropical America, and although the tree yields annually a large crop of capsules with silk-cotton, it is in most instances very difficult to gather for the reason that the regions where these trees grow to best advantage are usually almost inaccessible.

Another West Indian and Central American tree yielding silk-cotton is called Barrigon (*Pachira barrigon Seeman*). The wool obtained from this tree is identical with that of the Balsa and is seldom used for anything except for stuffing pillows, cushions, etc.

The Sumaumeira tree (*Eriodendron asmauna mart.*) so common along the Amazon, Rio Negro and Orinoco rivers yields a long-stapled silky-white cotton and could probably be made of service were it better known to textile interests. It is exceedingly light and is readily wafted through the air by the lightest wind. The Indians make beautiful fabrics of it, which seems to indicate that these fibers could perhaps be spun by our cotton spinning machinery.

The short, brownish cottony substance in the capsules of another tree called Ceiba (*Bombax ceiba Linn*) is used in the West Indies for making hats and bonnets, and for stuffing chairs and pillows. It is not made into beds, being too warm for those climates. Next to eider-down it is the softest material for use in stuffing.

The beautiful purple down of *Bombax villosum Mill* is spun and woven into a cloth of which garments are made and worn by the inhabitants of Mexico. This fiber retains its purple color without being dyed. *Bombax septenatum Jacq* is said to furnish the same kind of material.

There are two Brazilian species of trees which may become of interest to textile companies because of their possibilities as producers of silk-cotton fiber. These trees grow in regions where it is impossible or, at least, difficult, to raise ordinary cotton. One is called Barriguda (*Chorisia crispiflora Hth.*) (Fig. 4), is so named on account of the enormous swelling of its trunk immediately above the base, which is its chief distinguishing characteristic. The pods which contain the silk cotton are from 5 to 7 inches long and from 2 to 4 inches in diameter. The fiber is coarse and white and adheres closely to the seeds, which are somewhat smaller than peas. While the

fiber is long and rather strong it is too coarse for use in textiles of any degree of fineness. It may be used successfully in the fabrication of blankets, cotton twine, and a large variety of other material.

Imbirassu (*Bombax tomentosa St. Hill.*) is another tree which yields a much finer cotton, of a brownish color, exceedingly light, but hardly long enough to spin well. The seed pods in which the cotton is developed are about 10 inches long and 1 to 2 inches in diameter. The fiber is so light that it is easily wafted through the air by the slightest wind. The cotton is used for stuffing pillows and when properly prepared is as soft and downy as the lightest and best feathers, at the same time showing not the slightest tendency either to mat or to harden with any kind of use.

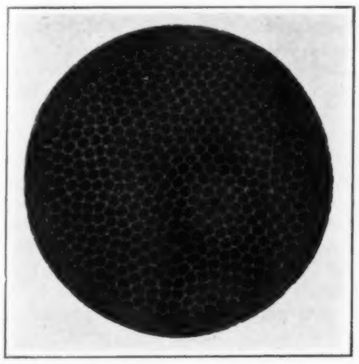
Cellular Structure in Liquid Films

A Peculiar Effect Produced by Heat

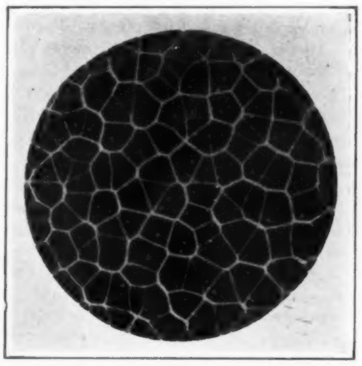
By the Paris Correspondent of the Scientific American

Several years ago a Paris scientist, M. H. Bénard, called attention to a fact which appears to have been hitherto unknown, namely, that when a liquid is heated under certain special conditions and in a very thin layer, the movements of the liquid under the influence of heat are quite different from the ordinary convection currents set up in liquids such, for instance, as when water is boiled. The best method to follow is to use a mercury bath with a rather large surface, this being heated in any suitable way, and the temperature carefully observed. Upon the mercury is a layer of wax such as beeswax, paraffine or the like, about 0.04 inch thick at most, for the effect is only seen in very thin layers of the substance. The bath is heated to temperatures varying between 75 and 100 deg. Cent. The use of the mercury gives a very flat surface so that the layer of melted wax is even and horizontal. As the bottom of the liquid is naturally at a higher temperature than the top, convection currents are set up in the liquid, but these currents take place in such a way that the whole mass of the layer becomes divided up into cells of hexagonal shape. In each cell, the heated liquid rises up at the central portion and the cold liquid descends along the walls. At the same time the surface is altered by these effects, the center of the cell becoming cup-shaped, while the hexagonal walls rise slightly, so that the pattern becomes visible to oblique vision. Thus it is an easy matter to observe the different shapes of these cells and the changes which they undergo at different temperatures, on account of the projecting hexagonal walls; for when a strong beam from an arc light is thrown on the surface of the liquid, the cell walls appear in a strong relief owing to the reflection from the mercury surface and also the refraction of the light by the various parts of the liquid.

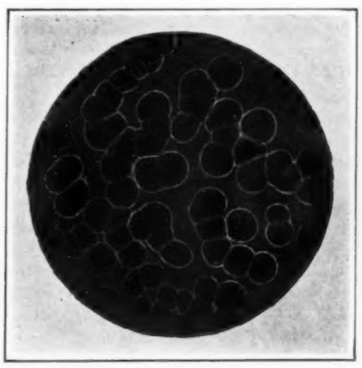
More recently the observation of this cell effect was taken up by Prof. C. Dauzère, of Toulouse, who has kindly furnished us with photographs and data regarding his experiments. The phenomenon here described has been used as a basis to account for some hitherto unexplainable facts, among others for the formation of the so-called craters of the moon. M. Deslanders, who is one of the best known of the French astronomers engaged in astro-physical research and is the chief of the Mendon observatory, considers that the cell effect may explain the way in which the moon's craters were formed, for he finds that some of the appearances given by the liquid cells coincide in a striking way with what he finds on the moon's structure. It will thus be seen that the present phenomena are of considerable interest. Prof. Dauzère first used the ordinary commercial beeswax of white color, this being first melted and filtered and then poured in a thin layer upon a mercury bath. The mercury is 3 inches thick and 8 inches diameter and is heated on the sand bath. When the wax layer is in place, the cells are soon formed when the temperature is kept for instance at 90 deg. Cent. The slight vibrations of the mercury due to concussions of the ground are not a hindrance, but rather favor the effect in overcoming the inertia of the liquid. The phenomena are quite different according to the temperature employed and the character of the wax. At a low temperature there is a less tendency for the cells to form. Starting thus with a few cells in the first place, when the heat is increased the cells begin to multiply in a way which is strikingly similar to what occurs with living cells in organic structure. Thus the wax cell originally circular, in form, gradually becomes elongated in one direction and constricted near the middle. A partition wall then forms across the middle, producing two cells side by side, whereupon each cell grows in size and finally the cells separate entirely and become independent individuals. Each of these multiplies in turn, so that the whole mass becomes covered in time. Such cells are formed in families of chains or groups, each group coming from an individual cell at the start, and in the first stages each of the groups lies apart and the groups are separated by spaces having a flat surface. Then the cells multiply so as to fill up all the spaces and cover the whole surface. Our engravings show the starting and multiplying of the cells. In some of the views the stage of cell division can be clearly seen. When all the surface is filled up, the cells have a more regular hexagonal shape than at first, as might be expected. These effects resemble very closely the action which takes place when a drop of culture bouillon is seen under the miscrope. The cells of ferments or microbes such as yeast and others grow and multiply in about the same way. It is found that the temperature materially affects the size of the cells. With beeswax (which melts at 61 deg. Cent.) and a 0.03 inch layer, there are 604 cells in an 11-inch circle at 100 deg. Cent. At 170 deg. Cent. there are only 282 cells. At high temperatures the cells become more irregular and lose their hexagonal shape, taking the form of irregular four-sided figures. Large and brilliant lines are seen as well as sets of faint lines and these divide up the surface as our photographs show. In general the action is as follows: When we heat the layer which has at first only some isolated cells, these begin to divide up and multiply so as to fill up the entire field. Then a continued heat causes the cells to increase in size and take an irregular shape, either with a network of cross-lines, or as individual cells separated by blank spaces.



Paraffine Wax at 82 deg. Cent. Forms These Small Cells in a Layer 0.87 Millimeters Thick.



Beeswax at 155 deg. Cent. Presents This Appearance. Layer 0.98 Millimeters Thick.



Paraffine Wax at 147 deg. Cent. Looks very Much Like Vegetable Cells, Even Showing "Nuclei."

The Palette of the Illuminator from the Seventh to the End of the Fifteenth Century*

In the opening lecture given at the Royal Academy of Arts last year, Dr. Laurie dealt with the question of the history of the pigments used at various times by painters, bringing together such information as could be obtained by a literary inquiry. Since then he has made an examination with the microscope of a large number of illuminated manuscripts at the British Museum, the Advocates' Library, Edinburgh, and the Edinburgh University Library, from the seventh to the end of the fifteenth century. The result of this examination has made it possible to identify the larger number of pigments used, and classify them according to the centuries and according to different countries, Byzantine, Irish, French, English, Italian, and German manuscripts having been examined.

The general results are to show that during these centuries the palette was practically confined to vermilion, whether natural or artificial, red lead, orpiment, ultramarine and ultramarine ash, azurite, malachite, natural and artificial, verdigris, lakes, and preparations of the nature of Tyrian purple, with the addition of a remarkable transparent green used from the eighth to the fourteenth century, which owes its pigmentary value to copper, although it has not been possible to determine exactly the nature of the compound. A green closely resembling it in appearance and properties can, however, be prepared by dissolving verdigris in Canada balsam or other semi-liquid pine resins. In no case were any specimens of the Egyptian blue which was used so largely in classical times found on the manuscripts. It therefore seems probable that the method of manufacture of this copper silicate was lost before the seventh century.

In addition to these pigments, earth colors were occasionally used, and there are rarely present some pigments which it is difficult to classify. The lake used after the thirteenth century is closely matched by lac lake, which was introduced for dyeing purposes about that time, and on the manuscripts of the late fifteenth century a fine lake appears, which in one case has been identified with every probability as madder lake. The tests, however, cannot be regarded as absolutely conclusive.

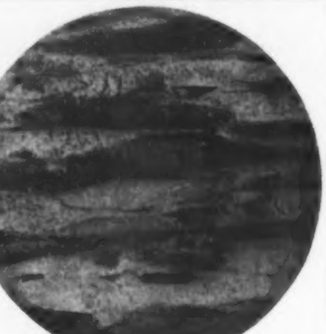
No fresh light beyond that contained in the known records can be thrown on the mediums used, with the exception that on one later fifteenth-century manuscript the medium has been proved to be beeswax.

All the pigments mentioned in the above list were not used in the same countries at the same time. It is possible to show a gradual improvement, for instance, in the preparation of ultramarine from lapis lazuli. The use of a fine verdigris is not found until the beginning of the fifteenth century, and azurites of different quality appear and disappear at definite dates, while a marked distinction can be drawn between the palette used in Byzantium and Ireland, and that used in the rest of Europe from the tenth century. There are also remarkable examples of the use of gold dust, while the laying of gold leaf on raised gesso does not appear earlier than the eleventh century, and only becomes common in the twelfth century.

The whole result of the investigation is to settle with considerable exactness the actual pigments in use, and it is probable that the results will be of value in assisting in fixing the dates of doubtful manuscripts.

It will be noted that the pigments are almost entirely mineral in character. They are in all cases coarsely ground, and the decorative effect is largely due to the coarse crystalline particles resulting in a broken surface.

* Abstract of the opening lecture delivered at the Royal Academy of Arts, and published in *Nature*.



The Hardness of Coins*

The Blow of the Die Renders the Surface Specially Resistant, While the Interior of the Coin Remains Softer

By T. K. Rose

HARDNESS is a word which is used in various senses. In dealing with metals, it sometimes means the cutting or scratching hardness, but is more often defined briefly as the *resistance to permanent deformation*, a property which is of great importance to all users of metals. It is this kind of hardness with which those engaged in minting are chiefly concerned. When a blank is struck in a coining press, the metal is compressed and at the same time forced to flow into the recesses of the dies, and the ease with which this can be done depends on the amount of resistance offered by the metal to a force momentarily applied and tending to deform it. The hardness should, therefore, be measured by the effects of a sudden blow, and falling-weight machines, such as Shore's scleroscope, offer a ready means of doing this.

The hardness numbers given below are scleroscope readings, about which it may be said that a piece of metal giving a higher reading is certainly harder than a piece of similar metal giving a lower reading, but that the readings cannot be taken as proportional to the hardness, except as a rough approximation. It cannot be admitted, for example, that a specimen with a hardness number of 40 is exactly twice as hard as one with a hardness number of 20.

The application of hardness tests to the coins of the realm has resulted in some curious and interesting data being obtained. It is found, naturally enough, that the blow of a coining press does not raise soft metal to a state of maximum hardness. A sovereign (£1) blank after annealing has a surface hardness of 25.5, and this is raised to 50–53 on being struck in an ordinary press, the maximum hardness of standard gold being about 76. Silver coins of similar size are hardened to much the same extent; but while sixpences, for example, have a hardness number of about 50, florins are only 37. These are the hardnesses of the "table" or flat portions of the coins, but the raised portions of the designs are much softer, especially the highest parts of large thick coins in high relief. Thus in George V florins the center of the effigy has a hardness of only 31, that of the annealed blank from which the coin is struck being 27.5. Such coins will evidently wear very differently from coins made in low relief such as the modern French coins, in which the surface hardness is higher and more uniform.

The hardness of the surface of coins, however, differs widely from that of the interior. The force of the blow seems to be expanded chiefly on the surface layers. When these are carefully removed, the hardness of the underlying metal is found to be considerably less. The hardness rapidly falls off with depth, and near the center even sixpences are almost as soft as annealed silver. Old worn coins are similarly soft.

It is clear, therefore, that a freshly-minted coin has a hard skin and a soft core, and that after the removal of the skin by wear, the loss of weight in circulation will proceed very much as though the coin had been annealed before it was issued. That this is a matter of some importance is illustrated by the fact that the loss by wear of the coinage, which falls on the State, amounts to £30,000 per annum for gold, and somewhat more for silver.

Annealing, one of the oldest processes practiced in the arts, has had a surprisingly small share of the attention which has been paid to metals by numerous observers in recent times. Experiments made at the Mint[1] with coins and coinage alloys gave such remarkable results that the experiments were extended to pure metals, and have enabled a fairly complete account of the course of events in annealing to be clearly stated for the first time. It appears, from a large number of observations that at comparatively low temperatures metals and alloys, hardened by rolling or hammering, are in an unstable condition, and undergo a gradual change to the soft state. The old standard silver and gold trial plates, for example, have in the course of centuries, at the ordinary temperature, become almost completely softened, while lead appears to soften below the ordinary temperature. As the temperature rises the change is hastened, and a *critical range* is passed through, varying in extent for different metals, below which annealing is too slow for practical purposes, while above it metals and alloys revert from the hard to the soft state almost instantaneously. During the critical range, the time required for annealing undergoes a significant reduction with each slight increment in the temperature, while above and below the critical range, the change in the time is small even with great differences of temperature.

Pari passu with softening, recrystallization takes place not by diffusion, but by a change in the orientation of molecules *in situ*, as predicted by Dr. Beilby. When the softening is instantaneous, recrystallization is almost, if not equally, instantaneous. Thus, for example, pure gold, which can be annealed in a few days in boiling water, softens at once at 200 degrees, and the large primary distorted crystals break up simultaneously into smaller irregular ones. (See headpieces). The gradual growth of crystals, which has been studied by Ewing and Rosenhain and others, takes place subsequently without much further softening.

* Reproduced from *Nature*.

[1] "The Annealing of Coinage Alloys," *Journal of the Institute of Metals*, September, 1912.

The Electric Arc Headlight for Locomotives*

Its Advantages and Disadvantages

By John G. D. Mack

DURING the earlier period of railroading in this country no attempt was made to run trains except during daylight hours, unless in case of emergency or delay. On account of the rapidly increasing traffic and the transportation of mail, it became necessary to establish night runs, which required some method for illumination of the track. One of the first devices appears to have been a fire basket, or a fire built on a platform in front of the locomotive. A more satisfactory illuminant became necessary as night runs became longer and more frequent, which resulted in the development of a headlight fitted with a reflector, which Kirkman states was first used on the Boston and Worcester Railroad in 1840. It is probable that lard or whale oil was used in the lamps of the earlier headlights, as mineral oil made from petroleum did not come into use until some years later. At this time, however, there was in use an oil distilled from coal, known as "coal oil," a term which still persists as a popular name for kerosene. The term "kerosene" was originally a name for a particular brand of "coal oil."

The common oil headlight of the present day is probably no better as an illuminator of the track than was its early ancestor, in fact it is not as satisfactory on the average, for in the earlier days of railroading, each engineer had his own engine and therefore felt responsible that all parts should be kept clean and the bright portions highly polished. This condition is impossible to maintain with present heavy duty locomotive requirements, under which the locomotive usually must be gotten out of the roundhouse with only such repairs as will enable it to pass the Federal or company regulations and get over the road. The oil headlight is said to be one of the few devices used in railroading which has received no improvement; if there has been a change it has been one of deterioration. The tendency of engineering as well as other affairs to run in cycles is illustrated by the return, in some degree, of the practice of having a certain locomotive assigned to a given engineer, who thus feels a pride and responsibility in the maintenance of his engine.

On the British and Continental railways the headlight is given small consideration, in some cases not being used. This is due to the fact that on these railways the public is absolutely excluded from the right of way except when aboard a train, or at carefully guarded crossings. The idea of the track being used as a promenade is unknown.

From the standpoint of the traveling public, the trespasser who endangers his life by walking the tracks, and those who of necessity are required to use highway crossings, the foreign practice relating to the protection of the right of way is greatly superior to ours.

In the year 1911, 5,284 persons were killed on the railway tracks in the United States who had no business to be there. This number excludes highway crossing accidents, accidents to employees and to the traveling public. The number of trespassers killed was 51 per cent of the total number of persons killed on railways in this country during the year named. During the ten year period 1902 to 1911, inclusive, the number of passengers killed on the railways of the United States was 4,340, and the number of trespassers killed was 51,083. There was not a single year during this period when the number of trespassers killed did not exceed the number of passengers killed during the entire ten-year period.

In the State of Wisconsin there are over 9,000 highway grade crossings, while within the city limits of Madison there are sixty-three such crossings, twenty-five of which are protected by some means, there being but two which are not at grade. However great may be the desire and necessity for better guarding of the right of way in this country, it will be many years, possibly many decades, before continental conditions are reached or approached, owing to several reasons, among which are the following:

The great area traversed by the railways, much of it in thinly settled sections of the country, renders absolute protection in all parts a matter of almost prohibitive expense.

The generally poor condition of the highways, especially in wet seasons, making them almost impassable for walking, requires those who walk to take the more direct and level track in preference to the muddy, dusty, circuitous or hilly highway, to prove which let anyone consult his own experiences in traveling afoot.

The average American citizen would probably resent an official command to get off the track, especially if it were the shortest and best footway to his destination, as he would resent much of the minute foreign police supervision of the citizen's acts, some of which doubtless would not be so effective in prolonging his life as if he were forced to walk on the highway.

In addition to the available human track obstructions just noted are the unavoidable obstacles, such as a washout, a car on a side track too close to the main line, criminal attempts to wreck trains, etc.

If a condition of track absolutely free from obstructions could be maintained, the headlight question would be of no consequence, but until that state of railway operation arrives, the headlight will be a subject for vigorous discussion.

At the present time locomotive headlights may be grouped in four classes according to the source of illuminant in the order of development, as follows:

1. Oil.
2. Electric arc.
3. Acetylene gas.
4. Metal filament electric incandescent.

*Reproduced from *The Wisconsin Engineer*.

The general design of the case is substantially the same in all, the principal difference in design apart from the illuminant being in the reflector, and in some cases the substitution of a lens for a front cover glass. The common type of reflector is of copper with a burnished silver plated reflecting surface, which usually becomes tarnished in a short time, owing largely to the sulphur in the coal. It is difficult to restore the silver to a good reflecting surface, particularly with the polishing materials available in the roundhouse. Some reflectors now on the market are made of glass, silvered on the back. The silver is thus protected against discoloring influences, while the exposed glass surface may readily be maintained in good condition, thus making a most efficient and durable reflector.

As the speed of trains increased a brighter illumination of the track was demanded in order to avoid accidents. Under normal conditions of track, a heavy train at sixty miles per hour may be brought to a stop in about 2,000 feet, this figure being very approximate, on account of the many variables which are involved in the problem. In any event the stopping distance of a train, even at moderate speed, is so great that the oil headlight is of no value in showing obstructions ahead in time to prevent accidents. Its value therefore is only that of a signal light of an approaching train and as a spreading light which gives the engineer some indication of his position by showing land-marks on or close to the right of way. In some cases the oil headlights are in such poor condition that they will perform neither of these functions.

A type of oil headlight has recently been developed which has a silvered glass reflector and front lens giving better illumination along the track than the old design, but the beam is of small diameter and outside its range the illumination is not as good as with the standard type.

The acetylene gives a much better illumination than the oil headlight, but the writer has not had the opportunity to observe one having a good reflecting surface which it is believed would add materially to the efficiency of this type. Even at its best, however, the acetylene light will probably not meet the demands of those who desire the powerful illumination ahead of the train which they believe will add to the safety of operation.

Incandescent lamps of the tungsten type which are used in automobile lamps give strong illumination but are just now beginning to be designed commercially for high power locomotive headlights and the writer has not had opportunity to make a test of this type. Powerful illumination of the character just noted is met at the present time only by the electric arc headlight.

The arc light had become a fair commercial success by about 1880, and naturally it was proposed to use it on locomotives, which was done so far as the writer can learn about 1885, on the Pennsylvania, and before 1890 it was tried on various other roads, the C. H. & D., I. D. & W., C. & E. I. and Vandalia, so that it is not a new device. The generator was driven by a reciprocating or oscillating engine and there were engine, generator and lamp troubles.

In present day designs a small turbo-generator set is used, the lamp is of simple construction, the operation of the three elements being satisfactory and quite free from the earlier troubles. In the lamp, carbon is used above for the positive terminal and copper below for the negative, automatic feed thus being required only for the carbon.

In some designs an incandescent lamp is fitted in the reflector; this may be cut in as the arc is cut out by means of a double throw switch in the cab, this change being made if thought necessary when meeting another train, or on entering a yard or terminal.

During the past ten years a number of States, through legislative enactment, have made laws specifying in various terms the requirements for locomotive headlights. Many of these laws have been such that the conditions imposed could be met only by the electric arc.

The Wisconsin Legislature during the 1911 session passed the following locomotive headlight law:

"Locomotive Headlights. Section 1809v. 1. It shall be the duty of every corporation operating any steam railroad of more than fifty miles of track within this State, to equip on or before July 1st, 1912, every locomotive, power vehicle, power car, and other equipment used as the equivalent of or in place of locomotives, except such as are used exclusively for switching service or in railroad yards and not elsewhere, with a headlight of sufficient candle-power, measured with a reflector, to throw a light in clear weather that will enable the operator of the same to plainly discern an object the size of a man, at a distance of not less than eight hundred feet, and thereafter to maintain and use such headlights upon every such locomotive, vehicle, car or other equipment, when the same is operated at nighttime."

The law contains an additional paragraph, which gives the penalty to be paid for its non-compliance.

During the past decade a number of headlight tests have been made by railroad officials and others interested in various phases of the subject. In order to have an independent basis for comparison, the Railroad Commission of Wisconsin ordered an extensive series of tests made by its engineering staff in the spring of the past year (1912). The committee having direction of the tests was selected from the Commission's engineering staff and consisted of the writer, who was at that time in charge of the mechanical department, as chairman, Mr. M. H. Hovey, safety service expert, and Mr. J. N. Cadby, inspector of gas and electric service.

An extensive series of tests was planned and performed during the spring and summer, with the co-operation of the C. & N. W. and C., M. & St. P. Railway officials, who furnished locomotives, headlights and provided clear track for the tests. Engineers, firemen, and other train men accustomed to the observation of signals and running conditions from both these roads and several others in the State were present at the various road tests, serving as observers with members of the staff of the Railroad Commission.

In some of the tests the observations of thirty observers were taken in order to determine average conditions. These tests were made with two types of oil, two sizes of acetylene and two makes of electric arc headlights. In testing the standard oil headlight, two were used, one being new with a highly polished reflector, and the other an older one with a tarnished reflector. The second type of oil headlight was one of recent development, having a silvered glass reflector and a front lens, both a 16-inch and 18-inch size being tested.

The distance tests consisted of the determination of the distance in which a man could be "picked up" when walking toward the standing locomotive, as well as when the man was stationary and the locomotive approaching him at various speeds. In order to determine average and extreme conditions, the observed men were dressed in white, black or neutral colors.

In addition to the "pick up" tests, observations were made on the influence of the headlights on signals, the visibility of semaphore arms, the effect on signal lights of various kinds as to reversal of color, the production of false reflections known as "phantom lights," and the observation of signal lights in the glare of a powerful facing light. Several extensive series of photometric measurements on the headlights were conducted by Mr. Cadby.

As this discussion deals particularly with the electric arc headlight, the arguments for and against this light will be given, as derived from laboratory and road tests, opinions, and experiences related by railroad men interested in train operation, practically every one of which arguments will find a disputant.

Statement of the case for the electric arc headlight:

(1) Good illumination of the right of way for a sufficient distance ahead to prevent or reduce damage from an obstruction.

(2) Warning of an approaching train.

(3) Light sufficient to show position of semaphore blade.

(4) Practically daylight conditions increasing the safety of operation.

Statement of the case against the electric arc headlight:

(*a*) An engineer looking from the cab into the field of an electric arc headlight, and at intervals of three quarters of an hour meeting a similar headlight, loses in two hours' time the power to distinguish colored lights.

(*b*) Classification lights (on the head end of the locomotive) are practically obliterated if the same locomotive carries an electric arc headlight. In one of the Wisconsin tests, out of 182 observations at 600 feet on a locomotive carrying an arc headlight, not a single classification light was observed.

(*c*) The electric arc does not ordinarily show obstacles on the track at a sufficient distance to prevent the probability of an accident.

(*d*) The electric arc may indicate a false or phantom light when the light behind the roundel is extinguished and in some cases a green or other colored phantom was observed when a light was burning behind a red roundel.

(*e*) When an observer is facing an arc headlight, practically everything beyond is blanked.

(*f*) It is impossible to estimate the distance from the observer of an electric arc headlight, which causes confusion at grade crossings.

(*g*) The electric light is confusing in yards and terminals to those not behind it.

(*h*) It is injurious to the eyes.

(*i*) In time of sleet, snow, fog or rain the reflection from these elements prevents observation ahead.

(*j*) Fusees disappear in the rays of the electric arc.

(*k*) The substitute incandescent controlled by a switch in the cab is unsatisfactory, as it is not likely to be used at the right time for those not on the engine, and it gives another duty to the overburdened engineer.

(*l*) Dependence cannot be placed on reading the semaphore blade positions by the electric arc. The rules of some railroads forbid the use of blade readings from sunset to sunrise.

(*m*) The reading of disk signals under illumination of the electric arc would be very hazardous.

The above are probably not all the charges which could be made against the electric arc headlight, but it is a strong arraignment as each charge is supported by recorded observations or expert opinion. If the case is not examined from other angles it would appear to be criminal practice to employ such a headlight on a locomotive.

The writer has endeavored to make a compilation of accidents chargeable directly to the electric arc headlight but with no great degree of success, and would be glad to receive specific instances from readers of this article.

Two cases are reported as occurring the same night on one road in Wisconsin during one of the floods last summer, in both of which the electric arc headlight showed a track washout at sufficient distance ahead to prevent injury to life.

One official on a road using this headlight said that he could not give an instance of a wreck caused by the arc headlight but could give a long list of accidents prevented by its use.

The "phantom lights," which all investigators have found, appear to be rather peculiarly the product of laboratory investigation as dangerous phenomena, for they have been seen by locomotive engineers and regarded as fairly harmless as long as arc headlights have been used. Public attention was not directed to them until they were carefully studied in the laboratory, or under laboratory conditions in road tests.

If locomotive engineers did not so regard the phantoms, train operation at night with the arc headlight would be rather intermittent. Possibly no locomotive engineer has analyzed his solving of phantoms to any greater extent than any one has studied the mental processes involved in crossing a street in the middle of a block crowded with rapidly moving traffic.

In regard to brilliancy of the arc headlight it may be noted that the eye has grown accustomed to artificial light of many times the intensity of that which sufficed a decade or more ago. We are not only accustomed to this increased light intensity but continually demand a brighter and brighter light.

Special training, as in the case of the blacksmith, permits him to determine with fair accuracy the heat of a piece of steel in a fire in which the ordinary observer can see nothing but a bright glow, and which partly paralyzes the latter's vision for many seconds.

One of the most conclusive charges brought against the electric arc headlight is (*b*) the obliteration of classification lights.

It is to be noted however that the classification light may be seen if the arc is switched off or if this is not done it may be observed after the bright beam has passed. In addition, the whistle signal is used for the same indication as the classification light and replied to by the engineer on the side track. Thus always giving protection and double protection when the classification lights can be seen.

There doubtless are conditions under which the arc headlight is unsatisfactory, but many locomotive engineers who have run behind it, some of them for years under various conditions, give strong testimony as to the value of this form of track illumination as a safety device and one questions whether there is a more competent authority. It is certain no one has a greater personal interest in avoiding collision with obstructions ahead of the train than the man on the locomotive, for in case of such collision he gets the worst of it.

As the area traversed by a railway becomes more highly developed, the necessity for a powerful headlight decreases, due to the elimination of grade crossings and the adoption of more careful protective measures. The increased density of rail traffic and the increasing number of parallel tracks under these conditions intensifies the valid objections to this form of headlight. Without attempting argument in further detail, the following point may be noted:

There are over 20,000 electric arc headlights in operation on single and double track roads, so that it would appear that if even a part of the above case against this light were in full effect, wrecks due to it would be of nightly occurrence and every electric arc headlight would be taken off in a week.

Radio Telegraphy

We read in *Umschau* that the English Engineer Bigham has recently invented an apparatus by means of which 30,000 words per hour can be transmitted telegraphically. The messages must be previously prepared and are then reeled off and dispatched somewhat after the manner of a moving picture reel.

Substitutes*

By O. Becklestein

It is often said that this is the age of substitutes, and with the word substitute a notion of badness, or inferiority, is usually connected. Yet to substitute for one thing another which is the perfect and complete equivalent of the former is not open to objection, and the contemptuous meaning attached to the word substitute is the less justifiable because the usual object and effect of substitution is to give the poorer classes of the community equivalents for rare and costly commodities. But distinctions must be made among substitutes. Some of them are, in the strictest sense, full and perfect equivalents for their prototypes, while others are worthless and harmful imitations, which should be classed with adulterations. Between these two extremes are substitutes of many grades, most of which do not deserve condemnation, but are of great economic value. Many substitutes, indeed, must be regarded as indispensable.

One of these, and perhaps the best known, is margarine, a substitute for butter which, although it does not possess exactly the food value and other qualities of natural butter, yet approximates closely thereto—in its better grades, at least—and must, therefore, be regarded as a very good substitute. Margarin fills an important place in the diet of the poor, who cannot afford to use natural butter in considerable quantities. The importance and the need of this substitute are proved by the fact that margarin to the value of twenty-five million dollars was produced, in Germany alone, in the year 1907, in addition to an approximately equal value of other butter substitutes, made chiefly from cocoanut and other vegetable oils.

Coffee substitutes are equally indispensable. It is said that Frederick the Great offered the first futile incentive for the production of a substitute for coffee, which in his time was very dear and drew much money out of the country. The annual consumption of coffee substitutes in Germany is now more than 200,000 tons, and greater than that of genuine coffee. There are numerous coffee substitutes, which differ greatly in composition and excellence, but all possess the merit of being free from caffein, and consequently more wholesome than natural coffee. This is one of the few cases in which a substitute is better than its prototype in any way. The same merit is possessed by natural coffee from which the caffein has been extracted, but this product is more costly than coffee in its natural condition.

Among the best of substitutes are synthetic camphor, indigo, perfumes, gems, etc. Synthetic gems, identical with natural gems in chemical composition and structure, must be sharply distinguished from imitations composed of colored glass and the like.

In agriculture, artificial fertilizers, including the new products obtained from atmospheric nitrogen, are perfect substitutes for barnyard manure and have become indispensable.

Products which vary greatly in character and value are offered as substitutes for certain articles, champagne, for example. Genuine champagne is a sparkling wine made in France by a peculiar process from grapes grown in certain districts. Taxes, duties and transportation charges make French champagne very expensive in Germany and other countries. If, however, the same wine is exported in casks, in the "still" condition, i. e., before the second fermentation, the duty and the cost of transportation are greatly diminished, and if the wine is then bottled and treated by the orthodox French process, the "champagne" thus produced is almost identical with champagne made entirely in France, for which it is an excellent substitute. "Champagne" made by the same process from the best German wine of similar quality must be regarded as inferior to the above as a substitute for genuine French champagne, although it may be a very good sparkling wine. But when wine of poor quality is dosed with sugar and converted into a sparkling wine in some mysterious way, the product is not a substitute, but only a worthless imitation of champagne.

A similar gradation exists among cognac substitutes. Pure grape brandy, even if it is made in Germany from German wine, may be regarded as a worthy substitute, if its "bouquet" closely resembles that of genuine French cognac. Even a mixture of pure grain or potato spirit with water and essential oils may rank as a passable substitute of greater or less merit, according to the closeness with which the cognac "bouquet" is imitated.[1] But when part of the alcohol is replaced by extract of pepper or tobacco which simulate alcoholic strength by burning the throat, the product is a worse than worthless imitation and should be fully exposed.

The employment of a substitute for a substitute is not uncommon. Margarin is a case in point. At first, about forty years ago, it was made, according to the formula of its inventor, the French chemist, Mège-Mouriès, from oleomargarine extracted from the kidney fat of beeves, but cottonseed, sesame, peanut, palm and other oils were soon substituted, partially or wholly, for the original raw material.

In paper making, a satisfactory substitute for a substitute is still being sought. Long ago, the increasing demand for paper made it necessary to find substitutes for the original raw material, linen rags. Now the forests are threatened with extinction and wood pulp is becoming scarce. Straw, peat, Manila hemp, esparto grass and other tropical fibers have been tried, but no substitute for wood pulp, satisfactory in quality and quantity, has yet been found.

In the textile industries cotton is a very important substitute for linen and wool, and artificial silk has lately attained considerable importance as a substitute for natural silk. Cotton is so indispensable a substitute that we have almost ceased to regard it as a substitute.

Indispensable, also, are preserved foods, as substitutes for fresh foods, and checks and banknotes as substitutes for coin. Substitutes play important parts in building. Brick, which was used in place of stone in very ancient times, is probably one of the oldest of substitutes. Now concrete, sand, lime, brick, and other compositions are employed as substitutes for natural stone and claybrick and molded ornaments of terra cotta and concrete form cheap and effective substitutes for costly stone carvings.

This brief and incomplete survey shows that we really are living in an age of substitutes, but it also shows that substitutes are universally used, indispensable and not necessarily evil. It is unfortunate that the term "substitute" has been brought into discredit by its application to fraudulent and worthless imitations, and it may also be regretted that the employment of a substitute is ever compelled by the scarcity of any commodity, but we should not, for these reasons, condemn substitutes in general.

* Adapted from *Prometheus.*

[1] This is not in accord with American opinion or, let us hope, with American practice. Even the most perfect and innocuous substitute should be sold for what it is, and not as the original article.

Ultra-Microscopic Parasites*

Some fourteen years ago Loeffler, of Greifswald, recognized the existence of micro-organisms, which were so minute as to be invisible with the highest available magnification, in the swollen blebs which appear in cattle afflicted with foot and mouth disease. Such parasitic forms are of such dimensions as to be not microscopic, but ultra-microscopic, and, unlike those bacteria which are the infective agents of tuberculosis, diphtheria or typhoid, they are able to traverse the physical pores of the finest filters. Some idea of the size of these filterable parasites, which are known to be the cause of such diseases in man as yellow fever or epidemic infantile paralysis, may be obtained when we consider that the ordinary microscope has a limit for the recognition of objects which are within the range of visibility. The highest magnification at the present time which is possible with the most perfect microscopes is about 2,250, or, in other words, an object which is 0.0014 of a millimeter is just visible by transmitted light when inlarged 2,250 times. Particles smaller than this belong to regions which are ultra-microscopic, and they are seen by reflected light cast upon them by special methods of illumination. With the ultra-microscope bodies as minute as 0.000005, 0.000010 of a millimeter, can be detected.

At the present time no fewer than eighteen diseases have been investigated which are believed, with good reasons, to be caused by filterable ultra-microscopic forms of life, the probable size of which may be less than 0.0014 and greater than 0.000014 of a millimeter.

These filterable parasites have not yet been obtained in artificial cultures. With the exception of the organism that causes yellow fever, which is known to pass a stage of its existence in mosquitoes, and therefore is probably a protozoon, the ultra-microscopic parasites are bacteria, which, with the exception of those of yellow fever, dengue, and epidemic infantile paralysis of human beings, are the cause of various contagious maladies of domesticated animals, for example, foot and mouth disease, cattle plague, rabies, cow-pox and chicken plague. Another disease, that of the tobacco plant, known as mosaic disease of tobacco, has been shown to be due to the agency of a filterable parasite.

Though ultra-microscopic in size these parasites have not been recognized with the ultra-microscope. The sole criterion of their presence is the power to produce infection, and the degree of infective power is almost fabulous. Foot and mouth disease can be established in a healthy calf with .005 of a cubic millimeter of the lymph from an infected animal, and the blood of fowls suffering from chicken plague is capable of conveying the disease after the blood has been diluted 1,000,000,000,000 times.

The introduction of any chemical substance, or of any known virus such as snake venoms or the toxins of bacteria, into the body is never followed by an increase in amount. If distributed throughout the body, it becomes practically unrecognizable. Further, the specific effects of such substances take but a short time to produce definite signs of their presence. The case is quite otherwise with filterable parasites. From the moment of inoculation a lengthened period of time elapses before any change is observed, and in the case of infantile paralysis this may be as long as five weeks; the marked symptoms of the attack then appear quite suddenly, the entire nervous system in many cases being so affected that any part of it will, if reinoculated into another animal, again produce a similar outbreak of disease.

* Reproduced from *Bed Rock.*

The Nobel Prize

We learn from *The Chemist and Druggist* that Prof. P. Sabatier, professor of chemistry at the Toulouse faculty of sciences, has decided to give his portion of the Nobel prize to the Toulouse Institute of Chemistry for the purpose of defraying the cost of new buildings for the institute.

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